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BULLETIN No. 397 JUNE, 1939

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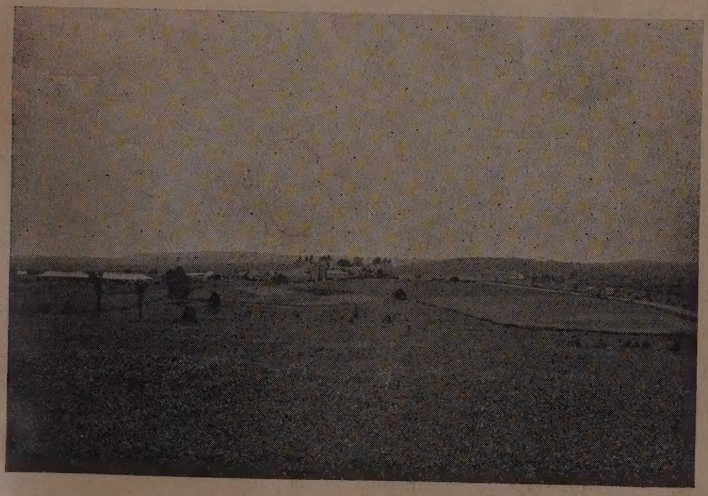
The Maine Agricultural Experiment Station

ORONO

Report of Progress for Year Ending June 30, 1939



Ladino clover (in foreground) at Highmoor Farm, Monmouth, Maine. Dairy-Show tent in the background at left

UNIVERSITY OF MAINE
THE MAINE AGRICULTURAL EXPERIMENT STATION
ORONO, MAINE

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BULLETIN 397

INTRODUCTION

The progress of the research program of the Station is given in this report for the year 1938-1939, together with pertinent financial statements and weather data.

APPLES

Apple Breeding Investigations. *Comparison of Solid Blush and Striped Strains of McIntosh.* Russell M. Bailey and Iva M. Burgess. In the orchards at Highmoor Farm are two definite strains of McIntosh, one with a clear, uniformly colored blush fruit and the other exhibiting definite striping. Some growers have speculated as to comparative yield and fruit size of the two strains. In 1938 a study was made of yield and fruit size in which 21 "solid blush" trees throughout the orchard were compared with a like number of "striped" trees similarly located. Student's method of paired comparisons was used to analyze the data. No significant difference in yield or fruit size could be demonstrated for the 1938 crop.

Apple Scab Control. Donald Folsom. Apple scab control was studied in two orchards on Highmoor Farm, with special attention being given to the growth rate of the trunk and the yield rate of fruits as affected by spray and dust materials.

Twenty-five-year-old McIntosh Trees. In 1938, for the fourth successive year, two rows of 25-year-old McIntosh trees, 20 to a row, were compared when receiving two different strengths of lime-sulphur spray respectively. Both rows were sprayed with the same equipment and on the same dates, and with the same strengths of mixtures as in 1935, 1936, and 1937. About 2,000 leaves and 4,200 apples were examined, and other measurements made, with the following general results:

Strength	Full	Half
Leaves scabby	2.7%	5.3%
Leaves burned	17.4%	12.6%
Fruits scabby	1.1%	1.6%
Fruits cull-scabby	0.4%	0.6%

Fruits russeted	4.3%	3.7%
Fruits clean	94.6%	94.5%
Average trunk girth in spring	64.3 cm.	64.3 cm.
Average girth increase	3.2 cm.	3.3 cm.
Fruit yield per tree	3.4 bus.	2.9 bus.

By full strength is meant one gallon of liquid lime sulphur or four pounds of dry lime sulphur to 50 gallons of mixture.

None of the differences shown above, between the full-strength and half-strength rows, were significant statistically. Although excessive rain during the first part of the season increased scab on the leaves, the fruits were well protected by the lime sulphur at both strengths.

The average of the four years' averages with respect to different characteristics has been as follows:

Strength	Full	Half
Leaves scabby	2.1%	5.1%
Leaves burned	33.0%	24.5%
Fruits scabby	2.0%	5.0%
Fruits russeted	2.7%	2.4%
Fruits clean	95.4%	92.7%
Fruit yield per tree	6.73 bus.	6.75 bus.
Clean fruit yield per tree	6.42 bus.	6.26 bus.
Girth increase	3.0 cm.	3.0 cm.
Final girth	67.5 cm.	67.6 cm.

Previous to this four-year test, with similar treatment for the two rows, the full-strength row yielded 21 per cent more than the half-strength row, so that the dilution of lime sulphur may be considered to have resulted in an increase of at least 21 per cent, or about 1.17 bushels per tree per year, giving a net increase of about one bushel of clean fruits per tree per year. However, to prove that this gain is due to the dilution of the lime-sulphur mixture will require a demonstration that the full-strength row will again surpass the half-strength row when both are again given identical treatments. Also, it should be pointed out that with different machinery or less thorough application of the fungicide the use of the half-strength mixture might not be so effective as indicated above, especially in years when scab is severe.

Young McIntosh Trees, Eleventh Year. In 1938, 338 young McIntosh trees were continued in several series. Each series

received the same spray or dust treatment for the eleventh consecutive season, except for one series, which was changed from a lead-arsenate treatment to a lime-sulphur treatment in 1936. About 99 per cent of the trees produced blossoms, about 89 per cent produced fruits, and the average yield rate of fruits for all trees was about 29 pounds per tree.

On August 2, about 1,800 leaves were examined in each series of trees, 100 leaves to a tree. At harvest time about 10,000 fruits were examined. Results are given in Table 1. The unusually high ratio of leaf scab to fruit scab is probably due in part to the first part of the season being much wetter than the second part. Noteworthy are the perfect control of scab on over 2,000 fruits by "micronized" sulphur spray (applied at an excessive rate) and the russeting of 11 per cent of the fruits by sulphur dust.

TABLE 1

Current-Season Effects of Spray and Dust Materials on Apples, 1938

Treatment	Per cent leaves scabby	Per cent leaves burned	Per cent fruits scabby	Per cent fruits russeted	Per cent fruits clean
Dry lime-sulphur spray	3.2	20.0	0.4	9.7	89.9
Ditto; lead arsenate to 1935 inclusive	2.1	18.9	0.3	5.5	94.2
"Micronized" sulphur spray	5.9	1.2	0	4.3	95.7
Bentonite sulphur dust	5.5	2.0	1.0	11.4	87.7
Only lead arsenate for tent caterpillar and gypsy moth	40.7	23.3	68.4	0.6	31.4

The cumulative effects of the various spray and dust treatments applied during consecutive years are shown in Table 2. Although there is not 5 per cent difference in trunk girth between any two series, the average yield per tree in 1938 was nearly four times as great for the sulphur spray and dust series as for the two lime-sulphur series, and the average yield per tree for all bearing years together is twice as great for the sulphur spray and dust series as for the two lime-sulphur series. The greatest difference between series noted in trunk girth was not significant, while the differences in yield rate between the sulphur spray and dust series, on the one hand, and the lime-sulphur series, on the other

hand, were significant, most being highly significant. In other words, the lime-sulphur treatment had no effect on wood formation but certainly had a great effect on fruit yield, reducing it about 75 per cent in 1938 and about 50 per cent for the total bearing years so far.

TABLE 2

Cumulative Effects of Spray and Dust Materials on Apple Trees, for the Eleven Years Ending 1938

Treatment	Trees 1938		Trunk girth 1938			Blossoms 1938*	Fruits 1938		Fruits 1933 to 1938 inclusive	
	Total	Per cent fruiting	Increase (cm.)	Final (cm.)	Ratio of final		Pounds per tree	Ratio of yield rate	Pounds per tree†	Ratio of yield rate
Lime sulphur	67	88	4.30	35.5	101.4	4.06	10.7	25.0	47.0	45.3
Ditto; lead arsenate to 1935 inclusive	67	76	4.25	35.7	102.0	3.81	13.2	30.8	65.3	62.9
Sulphur spray	65	95	4.20	36.7	104.9	4.74	42.8	100.0	103.8	100.0
Sulphur dust	65	89	4.02	35.0	100.0	4.38	47.0	109.8	122.6	118.1
Only some lead arsenate	74	93	4.38	35.2	100.6	4.07	34.1	79.7	78.2	75.3

* Abundance of blossoms estimated May 20 in 7 grades from 0 (none) to 6 (most).
† Cumulative yield.

Some general relationships between tree size and other factors were studied on the basis of the tree records. The larger the tree, the greater was the increase for 1938 in circumference as measured, the correlation being highly significant in each series and in the whole orchard ($r = +0.610$). The larger the tree, the more it yielded in 1938, the correlation being significant in the lead-arsenate series and highly significant in each other series and in the whole orchard ($r = +0.486$). The larger the tree, the more it has yielded to date, the correlation being highly significant for each series and for the whole orchard ($r = +0.578$).

WINTER INJURY TO APPLE TREES. Merle T. Hilborn. The study of the recovery of winter-injured apple trees has been continued. In addition considerable progress has been made in establishing a supply of hardy stocks for orchardists who desire them. In co-operation with Dr. J. H. Waring, of the Department of Horticulture, approximately 2,900 piece-root grafts were set out in

the spring of 1938 using the following varieties: Hibernal, Virginia Crab, Antonovka, Charlamoff, Vermont 329, and *Pyrus baccata.* If fifty per cent of these become established, as expected, the planting will provide a supply of these various hardy stocks for further propagation until numbers are reached that will enable the orchardist to obtain them for commercial planting.

APPLE TREE ANTHRACNOSE AND PERENNIAL CANKER. Merle T. Hilborn. These two new canker diseases of apple trees have recently become established in Maine. Perennial canker *(Pezicula malicorticis* var. *perennans)* is known only in a few orchards in central Maine. It is very likely, however, that it occurs also in other localities in the State. Apple tree anthracnose *(Pezicula malicorticis)* is now widespread in the orchards of the State. According to observations now reported by certain orchardists, anthracnose first appeared about 1933 in the southern part of Oxford County, and at about the same time appeared also in Androscoggin and York counties. During the period of 1933 to 1937 the disease spread rather slowly in these growers' infected orchards. Then in 1938 it began to spread rapidly and new infections appeared in about thirty orchards widely scattered over Maine, whereupon its presence was brought to the attention of the Experiment Station. It is now present in almost every county where apples are grown on any large scale.

The cankers caused by anthracnose first appear on the bark of the tree as areas that are almost circular and that are sunken or roughened. Frequently several of these cankers will meet and form one large canker which girdles the branch or trunk. The infection occurs in late summer or early autumn, and the cankers enlarge rapidly the next season. As they enlarge they become elliptical in shape and depressed. When the cankers are two or three years old, part of the bark on the surface of the diseased area disintegrates, leaving the bark fibers stretched like small guitar strings over the infected area. The fruiting bodies of the fungus appear later in the season and these crack open exposing the spore-bearing masses of the fungus. The cankers do not enlarge much after the growth of the first year, and the tree forms a ridge of callus around the wound. The cankers seldom center around any kind of a wound as the fungus is capable of penetrating normal, healthy bark. (Fig. 42, A and B.)

FIG. 42. New canker diseases of apple. A and B. Cankers caused by apple tree anthracnose (*Pezicula malicorticis*). C. Perennial canker (*Pezicula malicorticis* var. *perennans*).

This disease in the West also causes a fruit rot. It first appears on the surface of the fruit as small, light brown, circular spots of rotting tissue. A young spot may have a pale green center surrounded by a zone of brown. The rot usually appears in storage, but in severe cases it may appear before the fruit is picked. It is frequently severe in fruit which has not been picked until late in the season.

The disease is most injurious to very young trees or trees just coming into bearing, and is rarely severe on trees much over 20 to 30 years in age. Usually it is most serious on trees under 10 years in age and after 10 to 15 years many trees develop apparent immunity.

On the West Coast, the spores that spread anthracnose are produced in the fall of the year. The disease is dependent upon climatic conditions for its growth and spread. Cool weather and rain together in the fall induce the production of spores that spread the disease to uninfected orchards and also cause new infections on previously diseased trees.

As anthracnose is so new to Maine, the experiments on control have not run long enough to yield any definite results. On the West Coast a satisfactory method of control has been worked out which consists in part of applying bordeaux mixture in the fall as soon as the fruit is picked and before the fall rains begin. Fall pruning is also essential for controlling the disease. It is advisable where possible to prune away all cankered branches. When large and important limbs of a tree show only a few cankers, the dead bark should be cut away and the wound painted with bordeaux paint. All the pruned branches or dead bark that is cut away should be burned. This pruning should be done before time for the fall spraying, if possible. Then the trees should receive a thorough spraying using 4-4-50 bordeaux with a quart of linseed oil included in every 50 gallons as a sticker.

This control is based on work done on the West Coast, and it is not known how the disease will act in Maine under different climatic conditions. Experiments have been started in several Maine orchards to test out this method of control, and various other spray materials will be tried in 1939. Until the period of spore discharge has been determined for Maine, it may be assumed to be helpful to spray the trees with bordeaux also in the spring at about the time of the delayed dormant spray.

If the disease acts here as it does on the West Coast, fluctuations in its severity may reasonably be expected, because climatic conditions influence the production of spores and the resultant spread of the disease.

On the West Coast it was found that some cankers did not respond to these control measures, but continued to enlarge year after year. No spray program was found that would control the fungus causing these cankers, and the disease was given the name of perennial canker or "false anthracnose." In the early stages of this disease it is difficult to distinguish between anthracnose and perennial canker, but several characteristics may serve as a fairly good means of differentiating them. Perennial cankers enlarge year after year, usually center around wounds of some sort, and are dependent upon woolly aphid attack for dissemination. Perennial canker is most serious on winter-injured trees. Apparently the black-hearted wood present in such trees is more susceptible to attack by this fungus. (Fig. 42, C.)

The chief means by which perennial canker is spread is by the feeding of woolly aphids on the newly formed callus growth around a wound. Thus the control of this disease consists mostly of controlling the woolly aphid. This has been accomplished on the West Coast by introducing a parasite from the East. In Maine, where this parasite is presumably native, the standard recommendation in the past for the control of woolly aphid has been nicotine sprays. It is not known how successful this will be in controlling woolly aphid in orchards where perennial canker may be a serious problem, and possibly the infestation of such orchards may present a new problem in woolly aphid control. However, it is felt that perennial canker will not be a serious problem in Maine as the woolly aphid has never been a serious problem with us.

INSECTS AFFECTING THE APPLE CROP. Frank H. Lathrop. Studies of the control of insects in Maine apple orchards were continued during the past year. The main features of the work are reviewed in the following paragraphs.

Aphids. There are four species of aphids that commonly attract the attention of Maine apple growers.

The woolly apple aphid, *Eriosoma lanigerum* (Hausman), is usually found clustered about wounds or cankers or in crevices in the bark of trunk and branches of the trees. The leaves and the

roots also may be attacked. In Maine orchards woolly aphids are most frequently found scattered in small clusters. Seldom do severe outbreaks occur. Probably the most important injury resulting from woolly aphids is the delay in healing of infested wounds and cankers.

The rosy apple aphid, *Anuraphis roseus* Baker, where it occurs, causes the leaves to become tightly rolled, and the infested apples are distinctly stunted and severely malformed. Occasional clusters of apples, characteristically dwarfed and deformed by rosy aphids, may be found in orchards of southern Maine. The rosy aphid, however, has not yet become a generally important pest in Maine orchards.

The apple-grain aphid, *Rhopalosiphum prunifoliae* (Fitch), normally occurs in small numbers in Maine apple orchards. Even when this species occurs on fruit clusters in excessive numbers, however, there is usually but slight curling of the foliage and little effect upon the growth of the infested fruit.

In the fall of 1938 large numbers of winged migrants of the apple-grain aphid were noticed on the trees at Highmoor Farm and in many orchards in southern Maine. Later in the fall the egg-laying females were present in numbers. In the spring of 1939, the growers were alarmed to find the developing apple buds infested by countless numbers of newly-hatched nymphs of the apple-grain aphid. Many of the fruit clusters became heavily infested, but no important injury was observed even in orchards in which no spray was applied for the control of the aphids.

The green apple aphid, *Aphis pomi* De Geer, is the most generally troublesome species of aphid in Maine apple orchards. Infested leaves often become severely curled, the growth of the terminal stems may be interfered with, and the accumulation of honey dew produced by the aphids may result in discoloration of the fruit. When the fruit clusters become infested early in the season, the apples may be stunted and malformed, but such injury to the fruit has not been observed commonly in Maine orchards.

The green apple aphid is primarily a pest of young orchards. In some cases older orchards may be infested, especially where the trees have been liberally fertilized to produce vigorous growth.

In most apple-growing sections the usual recommendation for the control of the green aphid is the addition of nicotine sulphate

to the delayed dormant spray. In Maine orchards, however, the delayed dormant spray may not necessarily be the most timely period for combating the green aphid. Here the initial infestation of green aphids on the apple trees in the spring generally is exceedingly light. When severe infestation occurs, it usually comes after the aphids have built up through several generations under favorable weather conditions.

From the standpoint of the Maine apple grower, the problem is to determine each season whether or not it is necessary to apply treatment for the control of aphids, and, if so, to which spray the contact insecticide should be added.

In an effort to gain more complete knowledge of the problems involved, a study of the green apple aphid was undertaken during the summer of 1938 on a block of small apple trees at Highmoor Farm.

The experimental studies conducted in 1938 showed that the first eggs hatched on April 23. The aphids developed twelve generations during the course of the season (Fig. 43). In the fall the

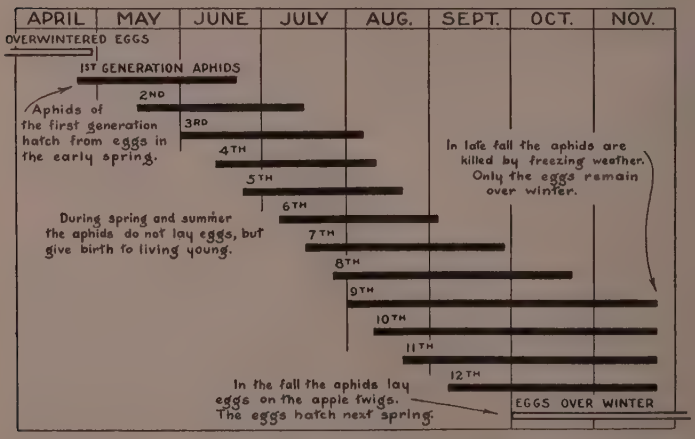

FIG. 43. Seasonal history of the green apple aphid, as observed at Highmoor Farm in 1938. It is interesting to notice that during the summer aphids of several generations were present on the trees all the time. For example, on August 1, seven generations were represented. Notice also the rapidity with which the generations occurred during the favorable conditions of midsummer.

first eggs were observed on October 1. Egg laying continued on the experimental trees until freezing weather killed the aphids.

It is planned to continue the study of apple aphids over a period of several years to develop information of value for combating the pest in Maine apple orchards.

The Apple Fruit Fly. In 1938 the infestation of fruit flies in commercial orchards was again generally slight. In some orchards, however, there was evidence of increase of infestation of the fruit as compared with the preceding year.

The emergence of the flies in the experimental cages at Highmoor Farm during the summer of 1938 was rather favorable for effective control by the application of insecticides. The first fly was observed on June 22. The numbers of flies that appeared daily increased gradually until mid July when the flies were emerging in greatest numbers. During the last two weeks in July, decreasing numbers of flies appeared, and after August 1 comparatively few flies emerged.

Experimental spray tests were continued. The primary object of the spray tests is to provide a basis for the most effective timing of the spray applications. The results have been helpful in advising when the sprays should be applied, but final conclusions should not be formulated until additional data are available.

The Gypsy Moth in Maine Apple Orchards. During the summer of 1938 the gypsy moth was more destructive than at any previous time during recent years in many localities of southern and western Maine. Many forest areas were heavily infested and the drifting larvae spread into nearby orchards. Unsprayed apple trees in infested localities were generally defoliated. In many cases the trees stood entirely leafless by the time the gypsy caterpillars completed their feeding period. After the caterpillars left, many of the trees developed new leaves, and some of the trees presented fairly good foliage in late summer.

In general there was little injury to foliage or fruit where the trees were protected by timely and thorough applications of lead arsenate in the pink, the calyx, and the first cover sprays.

Injury to bearing apple trees occurred most commonly where the prevailing air currents could readily transport large numbers of young gypsy moth caterpillars from infested woodland into the orchard, and the injury was especially severe where the trees

were in protected "pockets" into which the floating caterpillars settled, and from which they could not readily be blown away.

CANNING AND GARDEN CROPS

SWEET CORN BREEDING. Russell M. Bailey. The production of superior sweet corn hybrids to meet the need of Maine's canning industry is the primary objective of this work. A graduate fellowship, established in 1936 by the Maine Canners' Association, has aided the breeding work and has enabled the Experiment Station to provide technical assistance to Maine packers in the production of hybridized seed.

Many new crosses were under trial in 1938 and several appear superior to the Line 100 top crosses which are extensively used in the State at present for early varieties. Co-operative commercial trials will be undertaken to ascertain their value as soon as sufficient seed can be produced.

The results of the sweet corn hybrid and variety trials conducted at Highmoor Farm in 1938 substantiate the recommendations made in Maine Agricultural Experiment Station Bulletin 391, pages 248-249, 1938, concerning available canning hybrids for Maine.

SWEET CORN SPACING TRIALS. Russell M. Bailey. In an effort to determine optimum planting rates for different sweet corn hybrids used in Maine, co-operative work with the Maine Canners' Association has been undertaken. A study of the effect of different distances between individual plants on yield and ear characters has been in progress for two years. Canners' Golden Bantam strains, Line 100 crosses, and Top Cross Maine Bantam have been used as varieties, since these are most widely planted for canning in Maine. For experimental purposes all plots were thickly drilled and soon after plant emergence were thinned to the desired spacing. Plant spacing ranged from 4 to 16 inches between individual plants, with rows 3 feet apart.

Two years' data, 1937 and 1938, have been obtained and these appear to justify the following statements:

1. *Yield of cut-off corn per acre.* Under the somewhat droughty conditions of 1937 the 10 to 14 inch spacing (2.5 to 4.0 square feet per plant) gave best results for the larger stalked, later maturing Top Cross Maine Bantam. For the Portland Gold-

FIG. 44. Well isolated fields aid in the production of hybridized sweet corn seed. Seed is saved only from the detasseled variety planted between the male parent rows.

en Bantam and Portcross 100, which are smaller stalked and of earlier maturity, the 8 to 12 inch range (2.0 to 3.0 square feet per plant) appeared optimum. When more moisture was available in 1938, closer spacings gave better results, 6 inches for the earlier varieties and 8 to 10 inches for Top Cross Maine Bantam.

2. *Plant distance and ear length and size.* A very definite increase in ear size and length occurred both years for all three varieties when the distance between plants was increased. Maximum effect appeared to be reached at about the 12 inch distance for the small stalked varieties and at 14 inches for Top Cross Maine Bantam.

3. *Barren plants in close planting.* With close spacing a high per cent of the plants did not produce ears. An increase in the feeding area per plant markedly increased the number of ears produced per plant.

4. *Effect of close spacing on time of maturity.* Some records of silking dates, per cent milk in corn from different plots, and general observation suggest that thick planting will delay maturity one or possibly two days under average conditions.

5. *Effect of spacing on per cent cannable ears.* Within the range of practical plant spacing there was no definite influence of spacing on per cent cannable ears.

The data obtained thus far suggest that the optimum spacing distance is influenced considerably by soil moisture and fertility.

FERTILIZER EXPERIMENTS WITH SWEET CORN. Joseph A. Chucka and Stephen M. Raleigh. During 1938 experiments on sweet corn fertilization were conducted on six farms distributed throughout the sweet corn growing area of Maine. Data were obtained relative to fertilizer ratios, rates of fertilizer application, and effectiveness of nitrogen side dressings.

The 1938 experiments again indicated that the fertilizer treatment which produces the highest yield of sweet corn varies considerably with type and fertility of the soil and with the nature of the growing season. In general best yields were obtained when the fertilizer treatment consisted of 300 to 400 pounds of an 8-24-8 applied at planting time and was followed by a side dressing of 150 pounds of nitrate of soda applied when the plants were approximately knee high. Side dressings of complete fertilizer or of nitrate of soda-potash were little or no better than side dressing consisting of equivalent quantities of nitrogen alone in the form of nitrate of soda.

THE CORN EARWORM AND THE FALL ARMYWORM IN RELATION TO THE EUROPEAN CORN BORER SITUATION. John Hawkins. During 1937 corn earworms were present in many Maine localities where corn is grown for market and canning. During 1938 the fall armyworm was present in the same localities. During both 1937 and 1938 the European corn borer was also present though in smaller numbers than the other pests. The simultaneous occurrence of these pests in the same localities during the past few years has led to much confusion among growers who desire to protect their corn from excessive injury. This confusion has arisen because of the resemblance of the corn earworm to the fall armyworm. To a lesser extent the European corn borer has been confused with the younger stages of both the corn earworm and the fall armyworm. These three larvae which affect corn ears have been studied in order to help clear up any confusion which may now exist as to their identity. At the same time investigations were conducted on the effect of farm practices upon these pests.

The Corn Earworm, Its Appearance and Habits. The corn earworm attains a length of about 1½ inches and a diameter of

about ⅜ of an inch when fully grown. The corn earworm larvae vary in color from pale yellowish green to dark grey with pinkish stripes along each side of the body. The skin of corn earworms appears smooth but under slight magnification is seen to be roughened, and higher magnification reveals the fact that the skin is thick set with many small spines.

The corn earworms hatch from eggs which are laid on the silks of the corn ears. The small larvae enter the ears by way of the tip and thence down the silks to the kernels. Since they are ordinarily cannibalistic, it is seldom that more than one earworm is found in any given ear.

The corn earworms feed largely on the tip of the ear, but they may work farther down and destroy as much as half the kernels on an ear. Besides the corn which they eat, the earworms indirectly cause more destruction through the decay which often follows their depredations.

The corn earworms when fully grown make their way to the surface of the soil where they tunnel to a depth of six or eight inches and form a cell. In this cell the transformation from larvae to pupae occurs. The next spring the moths emerge and crawl to the surface through the entrance tunnel made during the previous fall.

Losses Caused by the Corn Earworm. Corn earworms seem to prefer sweet corn but occasionally attack field corn, ensilage and popcorn. Growers who market sweet corn are especially concerned since it is difficult to detect the presence of worms in the ears while the corn is being prepared for market. Growers and packers of canning corn are concerned because extra care and special labor are required to prepare the infested corn for packing.

Corn earworms come into uninfested areas of Maine by flight from infested areas farther south. These migrations do not occur every year and it appears that a certain amount of infestation may occur locally. Should such local infestation build up to serious proportions and at the same time be augmented by a heavy flight of moths from other areas, severe losses may be caused especially to those who grow green corn for the market and to the growers and packers of sweet corn. For this reason every effort should be made to control local infestations of the corn earworm.

Control of the Corn Earworm. Cultural practices in control of the corn earworm are based on the fact that the moths must perish unless they find their way to the surface either by way of the exit tunnel or some other opening. The moths cannot dig their way to the surface through solid earth. Thorough tilling of the soil after the larvae have entered the soil and before the moths have emerged will destroy the exit tunnels and control local infestations. Fall plowing being the usual method of corn earworm control employed should be thoroughly done. All stalks, grass, or other plant remains should be plowed under deeply and cleanly.

Further Control of the Corn Earworm. Artificial control for the corn earworm other than cultural practices has been tried with varying success. Clipping of the silks after pollinization of the corn ears has been reported as partially successful. The difficulty lies in timing the operation and in the amount of hand labor required. Dusting the silks of the corn with calcium arsenate and other insecticides also has been tried. Corn intended for feed should not be treated with arsenicals or other poisons dangerous to domestic animals.

Tablets containing a substance known as hexachlorethane and inserted in the ears have been reported as efficient in the control of earworms and might be worthy of consideration by market gardeners. Oil has also been used with success. The last two methods are new and likely to replace the clipping of the silks and the use of substances poisonous to humans. Since they are still in the experimental stage, they are recommended only as worthy of trial under Maine conditions.

The Fall Armyworm. The fall armyworm when fully grown is of about the same size as the corn earworm. It varies in color from light to dark grey. The back of the worm is somewhat lighter in color than the sides. The body of the fall armyworm is quite shiny in contrast to the duller and darker color of the greyish or greenish corn earworms. Except for the broad dorsal band, lighter colored back, and the dark stripes on the side, the fall armyworm has no distinct markings. The dull color of the fall armyworm serves to distinguish it from the more colorful corn earworm.

The Work of the Fall Armyworm. The young fall army-

worms ordinarily start their work on the leaves of the corn plant. As the plant becomes older they proceed to feed upon or in the stalk just below the tassel. This injury often causes the tassel to break over in a manner comparable to that caused by the European corn borer. The fall armyworm bores into the stalk and reaches the ear through its attachment to the stalk or enters through the side of the ear, near the base, but seldom through the tip. The way in which it enters the corn ear usually serves to separate the injury, and consequently the larva itself, from that of the corn earworm. In exceptional cases where injury is not typical, the surest way is to examine the character of the skin, remembering that the skin of the fall armyworm is smooth under magnification while that of the corn earworm is rough or spiny according to the amount of magnification used.

The fall armyworm works in the corn ear much like the corn earworm, once it has gained entrance to the ear, but often goes deeper into the ear and consequently causes trouble in corn intended for canning.

Control of the Fall Armyworm. The fall armyworm is more difficult to control than the corn earworm. Specimens of fall armyworms confined in cages have not been able to survive the winter in Maine. Investigators in other sections of the country report that it is possible for the fall armyworm to survive the winters only in the extreme southern part of the United States. This being the case it is useless to direct control operations against the overwintering larvae in Maine as is the practice for the control of the corn earworm and the European corn borer. Rather, control to be effective should be directed against the active larvae before they enter the corn ears. They can be killed with poison bran mash distributed on the corn or on the soil when the larvae are on the soil surface or on the corn plants before they enter the corn stalk or ears. Dusting or spraying with lead or calcium arsenate is effective if applied before the armyworms enter the stalks or ears. Corn intended to be used as feed for livestock of course should not be treated with dangerous poisons. Fortunately fall armyworm attacks occur only at intervals and control measures are necessary only occasionally.

Description of the European Corn Borer. The European corn borer attains a length of about one inch when fully grown.

Its color is usually cream or light brown, sometimes with a pinkish cast. It is sometimes confused with the corn earworm or fall armyworm in the young stages. Since the skin of the European corn borer is smooth, it can be distinguished from the corn earworm by the use of magnification. The lighter color of the European corn borer is useful in distinguishing it from the fall armyworm as well as the corn earworm.

Habits of the European Corn Borer. The habits of the European corn borer set it apart from other similar insects affecting corn. Early season feeding by the European corn borer is confined to the upper part of the corn stalk. It enters the ear through the stalk, only occasionally coming to the surface and entering the ear from the side. Damage done to the corn ear is lesser in extent than that of either the corn earworm or the fall armyworm. In spite of this considerable trouble is caused to the growers of market and canning corn because it is hard to discover the borers which sometimes work into the cob or beneath the kernels. Therefore extra care and labor are necessary in preparing the green corn for market and in processing it for canning.

Control of the European Corn Borer. Control of the European corn borer is accomplished by plowing under the corn stalks and other plant refuse in the fall before freezing weather sets in. It is necessary that all weeds and corn stalks in which the corn borers can winter over be covered completely and as deeply as possible. Weedy areas should be burned over so that weeds and grasses which serve as a host or shelter for these insects are destroyed.

Community Control Effective. Community efforts in control of the European corn borer are very successful when cleanups and fall plowing are done thoroughly and consistently over large areas.

Value of Control. While undoubtedly some of the borers are killed by inclement weather and natural factors, about 30 per cent of the larvae placed in experimental cages during the past winter survived. If 30 per cent of all European corn borers reaching maturity in nature survived under our conditions, growing corn in Maine would soon become hazardous. Consequently those interested in growing corn may well unite in a statewide effort to control this injurious pest.

General Aspects of Control. In conclusion it may be said that the practices of fall plowing and cleanup for control of corn earworm and European corn borer are also good practices for the control of many other insects, such as cutworms, wireworms, Mexican bean beetles, and many other insects. These cultural practices usually involve only a little extra care or a little more time than regular farm practices and are good from the general aspects of efficient agriculture aside from their value in insect control.

BEAN BREEDING. Iva M. Burgess and Russell M. Bailey. Several crosses have been made in an attempt to develop white-seeded snap beans of desirable type for canning purposes. From two of these, numerous progeny of both wax and green-podded have been selected and are being tested for quality.

The Old Fashioned Yellow Eye is a popular bean for canning as baked beans. Strain trials have shown those of the runner type to be much superior in yield and in freedom from disease to those of bush type. In some seasons, however, the vines of the runner plants may grow so vigorously as to cause considerable annoyance at harvest time in pulling and in curing. Crosses have been started using desirable strains of runner and bush types with progeny of disease-free plants involving disease resistant parents. From this material it is hoped that a desirable bush type strain may be obtained.

BEAN PLANTING RATE. Iva M. Burgess. The snap variety, Full Measure, was used in the planting rate plot. No conclusions can be drawn from one season's observations, but there seemed to be an indication that no increase in yield was obtained from plantings thicker than three or four plants per foot, also that the thicker plantings showed a decrease in Grade 1 pods at the factory.

BREEDING CUCUMBERS RESISTANT TO SCAB *(Cladosporium cucumerinum)*. Russell M. Bailey and Iva M. Burgess. In December, 1938, questionnaire blanks were sent to 102 cucumber growers who purchased seed of Maine No. 2, a scab resistant selection recommended for home garden trial. Over 70 replies were received as to its performance, and these were summarized in Maine Agricultural Experiment Station Miscellaneous Publication No. 554, 1938, which is available upon request. The replies indicated that this selection is satisfactory for home use but cannot be recommended for the market grower. The fruit is

intermediate between the pickling and slicing varieties in its season of maturity and in size. The fruit has black spines, is light colored, and yellows quickly after picking, all of which are undesirable in a commercial variety, but of little consequence in the home garden. Seed of a new selection, producing smoother, darker green, white-spined fruits, is available for limited trial as a possible scab resistant market variety.

VEGETABLE VARIETY TRIALS. Iva M. Burgess and Russell M. Bailey. The greater part of the vegetable variety work in 1937 and 1938 was done on privately owned farms in Cumberland and York counties where truck farming is done commercially. Some of the outstanding new varieties in these trials have been Imperial 847 and Imperial 44 lettuce, Honey Cream watermelon, Straight 8 and Ace (A and C) cucumbers, Early Prolific and Connecticut Straightneck summer squashes, Windsor A pepper, and New Hampshire Hybrid eggplant. Several tomatoes have appeared desirable. Among the better ones are Nystate, Clark's Early, Stokesdale, and possibly Redcap (only one year in trial). In the two seasons, one excessively dry and the other very humid during the early part and favorable for foliage diseases, Hutchinson was the most dependable carrot. Among the various spinach strains, there was as much difference between stocks of a variety as between varieties. In general, Longstanding Bloomsdale, Summer Savoy, and Aristocrat were about equally desirable for the midseason crop. Several sweet corn hybrids appear worthy of recommendation. Gemcross 13 is a fair to good quality, very early hybrid which yields well, producing a large ear. Marcross 13.6 (midseason), although only fair in quality, produces very attractive and large market ears. Seneca Golden (midseason) is of better quality, but produces a somewhat smaller ear. Golden Cross Bantam continued to be the outstanding, late season hybrid considering quality, uniformity, and type.

Tomato Planting Date. Iva M. Burgess. Four varieties of tomatoes, Canadian, Shirley Bonny Best, Marglobe, and Rutgers, were planted at approximately weekly intervals beginning March 28. In this one season the later plantings of Canadian were definitely superior in yield to the earlier plantings, while the reverse was true for Rutgers. The Bonny Best and Marglobe did not show such a regular trend.

Boron Deficiency in Rutabaga, Cauliflower, and Related Plants. Frederick B. Chandler, Joseph A. Chucka, and Irvin C. Mason. Studies have been made of the boron deficiency symptoms of 11 of the economic plants of the genus *Brassica*. All plants were supplied with boron for a period of 18 days or more. The symptoms of deficiency were found to vary considerably from one kind of plant to another of this genus. The only symptoms common to all kinds of plants were decrease in height of plant, in leaf length, in leaf width, and in total weight; and curling and rolling of the leaves. Other symptoms common to a large number of plants were rugosity of the younger leaves and a resemblance to cork on the surface of stems and petioles. Cracking of petioles and chlorosis of leaf blades were symptoms which occurred on a smaller number of plants. The economic part of the plant failed to develop when boron became deficient before that part started to develop. This part of the plant was the one most severely affected, regardless of what period of development was characterized by the withholding of boron from the plant. The detailed results of these studies will be published as a bulletin very soon.

Pea Aphid Investigations. John Hawkins. Injury caused by pea aphids to canning peas during the season of 1938 and 1939 was less extensive than usual. Peas were destroyed in only a few small areas in certain fields, and injury as a whole was light during the past season. Weather conditions favorable to the natural enemies of the pea aphid and at the same time unfavorable to rapid multiplication of the aphids was largely responsible for the small amount of damage caused.

The Pea Aphid Situation During the Past Year. Pea aphids were plentiful during the fall of 1938 and due to the lateness of freezing weather were present on clover well into November. Clover fields were found to be infested in May of 1939. Infestations on clover were light but evenly spread over the fields. During June the aphids migrated to peas and, as in the case of clover, the infestation although light was evenly spread over the peas throughout the pea-growing sections of the State. The pea aphid population increased steadily until about the middle of June and reached a point where the pea crop was threatened. Soon afterward a decrease in aphid numbers was noticeable. At about this

time syrphid maggots which are predaceous on pea aphids became very abundant. Tiny wasp-like hymenopterous parasites and fungus disease killed many of the pea aphids. Finally unfavorable weather conditions combined with parasites and predators decreased the aphid population to such proportions that the pea crop escaped with slight injury.

The Use of Insecticides in Pea Aphid Control. Experiments with insecticides for the control of the pea aphid were continued during 1938. Rotenone dusts with various wetting and spreading agents and nicotine were used in large field experiments. These materials, as well as others including insecticides used as sprays, were applied to peas in small short-row plots. No materials tried during this period gave satisfactory control of pea aphids. One important reason for the inconclusive results was that the aphids did not become sufficiently numerous to show differences in the treatments that could be considered significant.

Factors Influencing the Effectiveness of Rotenone Dusts. There has appeared a great amount of variation in the effectiveness of rotenone dusts used during the past three years in pea aphid control. This has been ascribed to several factors.

First, is the source and method of handling of the derris, or cube, containing the rotenone previous to its application as an insecticide.

In some instances the absence of a wetting and spreading agent has been considered to have impaired the effectiveness of rotenone dusts. The kind of material used as a carrier and the fineness of the diluent used also have been responsible for variations in the effectiveness of rotenone insecticides. The fineness of the materials contained in the insecticide is an especially important factor in the distribution and coverage of the dust. Until recently this point has not been given sufficient attention.

The presence of moisture at the time of the application of the dust and the length of the interval before rainfall which may wash the dust from the plants are factors of importance in the toxicity of rotenone used in pea aphid control.

Finally temperatures above 70° F. are necessary to the effectiveness of rotenone used as a pea aphid insecticide. This has been demonstrated in experimental plots during the past two years.

Oil in Combination with Other Materials as a Pea Aphid

Insecticide. Oil-bearing rotenone and nicotine have been used successfully in pea aphid control under laboratory conditions. These materials are being used also for the control of pea aphids in the field in other parts of the country. It is claimed that the oil-nicotine and oil-rotenone combinations do not depend upon the temperature for their success in killing aphids. This is especially important in Maine where comparatively low temperatures prevail during the period when insecticides used for pea aphid control should be applied. Experimental field work with oil-bearing rotenone and nicotine was carried on in Maine during the past season. Because of unfavorable conditions the aphids in untreated plots disappeared shortly after insecticides were applied to the treated plots. Since in the untreated check plots the reduction in aphid population was due to natural factors, the cause of disappearance of the aphids in the treated plots was open to question. It was impossible to tell exactly whether natural controls or the insecticides applied were responsible for the disappearance of the aphids.

Consequently further trials of these promising materials under field conditions should be made before definite conclusions can be drawn as to their practical use in pea aphid control.

CHEMISTRY

Work of Investigation. Elmer R. Tobey, Bernie E. Plummer, Jr. The work of this department is coöperative with members of other departments in the Station and includes the chemical analyses in connection with some of their projects. The results of these analyses are incorporated in the published reports of the respective research projects.

Strength of Mercuric Chloride Solutions Used in the Treatment of Seed Potatoes. During the past year considerable laboratory and field experiments have been carried on to compare the more common water solution of one part per thousand of mercuric chloride with the "acid dip" method of treatment. The mercury is removed rapidly by the potatoes from the water solution but the addition of a small amount of hydrochloric acid to the solution prevents this removal of mercury. The investigation was continued the past year with special emphasis on the "acid dip"

method. The strength of acid and concentration of mercuric chloride were varied, but the results indicate that a 0.2 per cent hydrochloric acid solution with two parts per thousand mercuric chloride is the most effective in retaining mercuric chloride in solution.

It is proposed to continue this investigation during the coming season in order to obtain further information concerning the possible injury to seed pieces and the effectiveness of disease control when the "acid dip" is used.

Mercury Absorption by Potato Foliage. Samples of potato foliage from experimental plots at Aroostook Farm have been submitted for analysis to determine, if possible, if any of the mercury, added to fertilizer to control diseases of potatoes, is absorbed by the plant and thus may become a source of contamination to the tuber. Considerable experimental work on the adaptation of a method to determine minute amounts of mercury in organic matter has been carried on.

The Conservation of Ammonia in Manure. In coöperation with the Department of Biology, a laboratory investigation and experimental work at Highmoor Farm have been started to study methods of conservation of ammonia in manure. A preliminary progress report is now ready for publication. This investigation is to be continued during the coming year.

Collaborative Research Work on Methods of Analysis, Association of Official Agricultural Chemists. The usual amount of this type of work has been carried on during the past year.

Miscellaneous Analyses. This classification includes analytical work which is not directly related to the inspection service or to any of the Station projects. The nature and the amount of the work vary from year to year, but the number of samples, accompanied by requests to test for poison, is increasing rapidly.

DAIRYING

AN ECONOMIC STUDY OF THE DAIRY INDUSTRY IN MAINE. George F. Dow. *Dairy Farm Organization and Management Studies.* A manuscript of the "Organization and Management of 95 Dairy Farms in Androscoggin and Oxford Counties" has been prepared by Andrew E. Watson and soon will be available for

publication. Another manuscript covering 214 dairy farms in central Maine is also being prepared by Dr. Rauchenstein, of the United States Bureau of Agricultural Economics. The data for these two manuscripts are for the year ending April 30, 1937, and were obtained through a coöperative project between the Maine Agricultural Experiment Station and the United States Bureau of Agricultural Economics.

Work also has been started on the detailed analysis of the 1,037 dairy farm records that have been obtained over a period of years in various areas of the State. These records include farms supplying milk and cream; combining different farm enterprises; producing farm products under favorable and unfavorable price relationships; and selling in different markets.

Milk Marketing Study. The analysis of milk distributors' reports, made available last summer by the State Milk Control Board, has been nearly completed and a manuscript is in preparation. The study includes 20,412 monthly reports by distributors of their receipts and utilization of milk and cream. The records include 29 markets in Maine and in most cases are for a period of slightly more than two and one-half years.

The study shows the present sources of supply and utilization of milk and cream in local markets. In the smaller markets nearly all the milk is sold by producer-distributors; but in the larger markets the producer-distributors handle only 26 per cent of the total volume of sales. Sixty per cent of the total number of distributors sold less than 50 quarts of milk equivalent daily, but they handled only 10 per cent of the total volume of sales. An increase in price of 1 cent per quart of milk had only a very minor effect on milk consumption. Sales of milk and cream did not show much seasonal variation except during July and August when consumption was increased about one-fourth for milk and one-half for cream, as a result of the influx of vacationists into Maine. The proportion of surplus milk varied from 14 per cent in August to 21 per cent in June, and averaged 16 per cent for the year. There was no significant change in the relative volume of sales by large and small distributors during the two and one-half years under State Control regulation.

Milk Marketing in New England. (Coöperative between the U. S. Bureau of Agricultural Economics and the six

New England Agricultural Experiment Stations.) Progress of study reported by Secretary of the New England Research Council on Marketing and Food Supplies, Proceedings of the annual meeting held April 26 and 27, 1939, at Boston, Massachusetts. "The compilation of data on the operation of country dairy plants in New Hampshire and Vermont. These data, obtained primarily from the State Departments of Agriculture, give a picture of the location, size, and type of country plants, the products received and shipped, the prices paid, the number of producers, and the seasonal changes during 1937. In conjunction with data summarized from the records taken by Schoenfeld in 1925, they show the changing pattern over a twelve-year period.

"The development of theoretical analyses of the various phases of milk marketing, especially those phases encountered in the movement of milk from farm to city plant. This work points out the inadequacies in our present information and indicates the type of data that is necessary to a study of country milk marketing reorganization.

"The inauguration of the study of the costs involved in operating country milk plants. Up to the present, work on this study has consisted of obtaining the coöperation of the various agencies that operate country plants, of investigating the type of material they have available, and of developing the cost picture for one sample plant."

FARM CREDIT

FARM CREDIT IN MAINE. Charles H. Merchant. During the summer of 1938, additional information on credit was obtained in northern and southern Aroostook County. This information was obtained very largely from farmers to supplement material already obtained from similar sources in central Aroostook to give a representative sample of agricultural conditions for the entire county.

The total farm real estate mortgage indebtedness for Aroostook County has been tentatively estimated at approximately twenty million dollars. The mortgage indebtedness has probably more than doubled during the past ten years. The amount of production credit extended varies from about 2.5 million dollars to

4 million dollars annually. Farmers on less productive land and who were located on poor roads distant from shipping stations found it more difficult to meet their financial obligations than those living on good productive soil conveniently located near shipping points.

In addition to information on farm credit conditions in Aroostook County, material has been assembled on such related subjects as prices received for potatoes and the general price level, yield of potatoes per acre and cost of production, and taxes and tax delinquencies. In the study of farm credit, consideration has been given to both the farmers and the creditors from the standpoint of a sound permanent system of agriculture and credit for Aroostook County.

FIELD CROPS

FIELD CORN VARIETY TRIALS. Russell M. Bailey. The work of testing new field corn varieties and hybrids was continued in 1938 with the addition of new material from several sources. Several new flint-dent hybrids obtained from the Wisconsin Agricultural Experiment Station appear to be of considerable promise at this time, and these are under more comprehensive trial this year. Minhybrid 402 and Minnesota 13 dents, although slightly later maturing than Maine-grown flints, appear to be sufficiently early to be worthy of trial by farmers in central and southern Maine. At Highmoor both have yielded considerably more than the flint strains and the strong stalks and strong ear shanks permit leaving the ears on the plant until they can be husked at picking.

For ensilage Cornell 29-3 has given excellent results in several coöperative trials with farmers and is highly recommended for this purpose.

SMALL GRAIN VARIETY TEST. Joseph A. Chucka and Arthur Hawkins. *Oats.* Eleven varieties of oats (Eagle, Gopher, Iogold, Ithacan, Lenroc, Maine 340, Minnesota Smut Resistant, Rainbow, Sovereign, Upright, and Victory) were included in the oat variety test at Aroostook Farm. Although the test was planted rather late (June 11 and 12) fairly good yields of oats were secured. Several of the new varieties equalled or slightly exceeded the yields produced by Maine 340 and Gopher but none

were sufficiently superior to be recommended in preference to Maine 340 or Gopher at the present time.

Wheat. Nine varieties of wheat (Apex, Ceres, Garnet, Marquis, Reward, Sartov, Sturgeon, Thatcher, and Canadian Accession Number 1005) were included in the 1938 wheat variety test at Aroostook Farm. As a result of the very severe rust epidemic all of the varieties of wheat produced very poor yields. Apex and Canadian Accession Number 1005 showed marked resistance to rust and produced the highest yields, but even their yields were unsatisfactory. Marquis and Garnet, the varieties most commonly planted in Maine, showed the greatest susceptibility to rust.

Barley. Eight varieties of barley (Alpha, Byng, Hannchen, Oderbrucker, Spartan, Trebi, Velvet, and Wisconsin 38) were included in the 1938 barley variety test at Aroostook Farm. The yields of all varieties were low due to an unfavorable growing season for small grains. Alpha produced the highest yield. Of the new varieties, Byng and Trebi (two Canadian varieties) show considerable promise.

FOODS AND NUTRITION

A STUDY OF THE FOOD HABITS AND NUTRITIONAL STATUS OF CHILDREN IN SELECTED COMMUNITIES IN MAINE. Mary M. Clayton. The long-time study of the children in the Newport grade school begun in the fall of 1936 was continued in 1938-1939. It had been planned to have the school physician examine the children as in previous years but owing to illness he was unable to do the work. As usual a general checkup and measurements were made by the Nutritionist and dental examinations were made by the Director and Assistant Director of Dental Health for the State Department of Health. In general the physical condition of the children was very similar to that found in the two previous years.

Data secured during the past three years have been partially summarized. The accompanying table gives a comparison of the results of measurements of the Mars Hill and Newport children and also includes a dental summary for Newport. The measurements were based on the system developed at the University of

Iowa Child Welfare Research Station by Dr. C. H. McCloy.[1] He is of the opinion that children more than 6 per cent under the average in weight (or more than 15 per cent over the average) for their build may be in need of medical attention. Underweight may be directly due to a relative lack of normal fat or to a relative underdevelopment of the muscles. A relative lack of normal fat is indicated when a child rates below −33 per cent; a relative underdevelopment of the muscles is indicated when he rates below −3 per cent. The table indicates that since 1936-1937 there has been a definite increase in the percentage of underweight children in Newport. With this increase there has been a decrease in the percentage of children who were below average on fat but an increase in the percentage who were below average on muscle. It will be noted that in 1936-1937 there were more underweight children in Mars Hill than in Newport, but since then the percentage of underweight children in Newport has about equaled that found in Mars Hill in 1936-1937.

TABLE 3

Summary of Results of Measurements (Iowa System) on Mars Hill and Newport Children and Dental Summary for Newport

	Per cent who were more than 6% underweight		Per cent who were more than 33% below average on fat		Per cent who were more than 3% below average on muscle		Average number cavities per mouth	Average number fillings per mouth	Per cent with inflamed gums	
	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Fall	Fall	Spring
Mars Hill 1936-1937	47.74	51.09	83.88	82.17	34.15	31.87	—	—	—	—
Newport 1936-1937	29.84	30.16	78.23	76.76	33.87	25.21	*8.4	*1.4	*10.7	—
Newport 1937-1938	50.40	37.34	63.09	61.80	48.81	39.48	*9.0	*1.3	* 7.0	*25.0
Newport 1938-1939	44.95	38.72	48.38	52.45	40.76	31.37	*10.0	*1.9	†17.9	†21.3

* Examinations made by Miss Dorothy Bryant, State Director of Dental Health.
† Examinations made by Dr. Philip W. Woods, State Director of Dental Health.

[1] Univ. of Iowa Studies in Child Welfare. Appraising Physical Status: The Selection of Measurements. Vol. 12, No. 2, 1936. Methods and Norms. Vol. 15, No. 2, 1938. By C. H. McCloy.

The above changes in the physical condition of the Newport children are very probably related to changes in economic conditions. There has been a great deal of unemployment in the town during the past two years which has necessitated the use of nutritionally inadequate diets by many of the families. Such diets tend to be deficient in quality rather than in caloric value.

The dental summary for Newport shows a slight increase each year in the average number of cavities per mouth. Since 1936 there has been a slight increase also in the average number of fillings per mouth. These results show that conditions causing decay of the teeth have grown worse although there has been a slight increase in the amount of corrective work done. In 1938-1939 there was only a slight increase between fall and spring in the percentage of children with inflamed gums, showing that the low vitamin C content of the diets and other factors causing the inflammation were operating at both times of the year.

During the past year a new health activity in Newport was the work of the school nurse from the State Department of Health. Her work has consisted chiefly of making audiometer tests (to detect hearing defects) at the school and visiting mothers regarding special health problems of the children. These problems were revealed by the school examinations made by the physician and the nutritionist. There seems to be considerable interest in health problems in Newport but until economic conditions improve and more educational work is done there will probably not be much improvement in the condition of the children.

THE RELATION OF THE DIETARY HABITS AND FOOD RESOURCES OF MAINE PEOPLE TO THEIR STATE OF NUTRITION WITH RESPECT TO VITAMIN C. Mary M. Clayton. Work on methods of study has been continued and has included the instruction of a physician from the U. S. Children's Bureau and a technician from the State Department of Health in the determination of vitamin C in blood and urine. These methods were used by them in the coöperative vitamin C study carried on this year at Fort Kent under the auspices of the U. S. Children's Bureau, the State Department of Health, and the State Experiment Station.

In the fall at Newport the study of the value of gum examinations as a method of detecting latent scurvy was continued. Sixty-eight children were tested by the 6 hour vitamin C satura-

tion test. Of 36 with inflamed gums, 44.4 per cent had a low saturation test showing that they were deficient in vitamin C. Of 32 with normal gums 25 per cent also had a low test. These results indicate that the appearance of inflamed gums very often is associated with vitamin C deficiency, but that a deficiency often exists in children with normal gums.

In the spring, 30 children, 27 of whom had inflamed gums, were given curative tests with 100 milligrams of pure vitamin C daily for 3 weeks. Mouth examinations were made previous to the beginning of the tests, after 10 days, and at the end of the 3-weeks period by Dr. Woods, State Director of Dental Health. Results indicated that only three of the children whose gums were inflamed at the beginning of the test did not show a cure or definite improvement as the result of the treatment. In several cases, however, complete cure was hindered by the presence of badly decayed teeth, malocclusion, or poor oral care. Both the vitamin C saturation test and the curative test were used in the Fort Kent study.

Work has been done also on the development of a method for studying the availability for human nutrition of the vitamin C contained in various foods. In a preliminary experiment on one subject, potatoes, cooked by baking and also by boiling with the skins on, were used as the test food. Results indicated that the vitamin was very well utilized, as shown by an increase in the amount in the blood and a slight decrease in the amount in the urine when one-half of the day's intake of the vitamin was taken as potatoes following a period when it was all taken in tablet form.

In preparation for the possible future use of rutabagas (which are high in vitamin C) as a test food in the above study, and also as a matter of importance to people in the State, the effect of various methods of cooking on the vitamin C content of this vegetable was studied. The following methods were used: steaming, cooking in a small amount of water and evaporating the water, panning (using a small amount of fat and no water), cooking in a larger amount of water until the vegetable was just soft, and cooking 90 minutes in a large amount of water. Results obtained by the indophenol titration method showed that the least loss of the vitamin (about 30 per cent) occurred when the rutabagas were steamed or cooked in a small amount of water and the water evaporated. Panning was the next best method, and cooking

for a long time in a large amount of water the worst. In the last method about 70 per cent of the vitamin was lost. It is probable that in the different cooking processes some of the vitamin is changed to the dehydro form which is still physiologically active but not determined by the indophenol method. This form of the vitamin can be determined only by the biological method or by more elaborate chemical methods than the one used.

THE RELATION OF MAN AND OF ANIMALS TO THE ENVIRONMENT. IV. W. Franklin Dove. (a) *A Research Program Based upon the Principle of Production for Use.* As indicated in previous annual reports[2], [3], [4] these experiments are centered on one major problem, i.e., the determination of the needs of the State and in turn the determination of the means to supply those needs. The needs of the State have been measured by means of several systems of statewide surveys and by means of an analysis of past and contemporary attempts directed toward adjustment. New and better modes of adjustment have been sought also through a laboratory experimental analysis of need-getting especially devised for this type of problem. The results of such an analysis direct the research projects toward the maladjustments which appear from the intercorrelations to be most in need of attention.

While the experimental technique devised has been applied to needs in general, the results may be applied also specifically to nutritional need, the biological phenomenon from which the technique has been, in part, derived.

From this combined method of analysis, local variations in rate of occurrence and in geographic distribution of nutritional deficiency diseases as well as variations in economic and financial abundance or lack of abundance with their relation to the occurrence of deficiency diseases have been correlated with the availability of and contiguity to the productive resources of the State.

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[2] Dove, W. Franklin. 1935. A study of the relation of man and of animals to the environment. I. Maine Agr. Exp. Sta. Bul. 380: 187-204.

[3] ———— 1937. A study of the relation of man and of animals to the environment. II. Maine Agr. Exp. Station Bul. 387: 197-201.

[4] ———— 1938. A study of the relation of man and of animals to the environment. III. Maine Agr. Exp. Sta. Bul. 391:253-267.

From the results of the first work on this project,[5] begun in 1926, attention was called to the widespread occurrence of rickets-like deficiencies with their effects upon bones and teeth. In this particular report the maladjustment was traced back through the biological linkage of climate-soil-plant-animal-man.[6] The corrections for these deficiencies were shown to rest in the hands of the producers and distributors of such foods as milk, meat, fish, and eggs as well as through methods of soil fertilization to increase the calcium and phosphorus content of the plant foods and crops in soil-depleted regions.

But in addition to the vitamin D deficiencies it also was early predicted that vitamin C deficiencies (scurvy) would probably be quite prevalent in this same region where citrus fruits are not grown and are not easily available to all.[7] According to statistics on crop production (see Table 4) foods known to carry the corrective factor and prevent scurvy (other than potatoes) were found to be produced in small quantity. Thus in 1920, although Maine produced eleven times as many potatoes as were necessary for her own people (according to food standards of a balanced and diversified diet), yet in the same year she produced only one-eighth of the necessary tomatoes, leafy green and yellow vegetables, fruits and berries. These latter foods are recognized as the most satisfactory source of the vitamin C for the prevention of scurvy because they are generally high in this factor and are also, in large part, consumed fresh and raw before the vitamin has been lost by oxidation. Even though one includes the gardens too small to be listed by census, it still should be said that the production of fruits and vegetables (other than potatoes) is below requirements be-

[5] Dove, W. Franklin. 1934. A study of the causes of nutritional deficiency diseases in the livestock and inhabitants of Maine with possible corrective methods secured from the . . . production of superior foods. Maine Agr. Exp. Sta. Bul. 375:191-284.

[6] Very recently the physical phases of this linkage have been summed up interestingly by Dr. E. C. Auchter in an article titled: "The interrelation of soils and plant, animal and human nutrition." Science 89:421-427, May, 1939. Another resumé of the interrelation may be found in the 1938 Yearbook of Agriculture, "Soils and Men," House Doc. No. 398, 75th Congress, 2nd Session. Wash., D. C., Gov't Print. Office.

[7] Dove, W. Franklin. 1932. The need for vitamin assay of Maine-grown varieties of fruits, vegetables, roots, and field crops. Report for the Maine Agr. Exp. Sta. Council.

TABLE 4

Market Production vs. Consumer Requirements of Fruits and Vegetables in the State of Maine

(In millions of pounds)

Census Year	Potatoes (white)		Tomatoes and citrus fruit		Leafy green and yellow vegetables		Other vegetables and fruits Strawberries Raspberries Gooseberries Plums and Grapes		Total fruits and vegetables other than potatoes	
	Required*	Produced†	Required	Produced	Required	Produced	Required	Produced	Required	Produced
1850	97	206								
1860	106	382								
1870	107	466								
1880	112	480								
1890	116	315								
1900	121	589								
1910	126	1,713								
1920	134	1,532	71	2.9	76	23	163	10	310	36
1930	139	2,486	74	5.3	78	30	169	8	321	43

* Required—Amount of each food required to supply an adequate diet at moderate cost,[8] corrected for sex and age distribution from population census data.
† Produced—Market production rates secured by census reports. Home production data not available.

cause of the class of foods usually grown and because of the large numbers of families without gardens in both cities and in areas of specialty production.

In 1930 Maine again over-produced on potatoes, this time eighteenfold, and still failed to produce much more than one-eighth of the fruits and vegetables known to be high in vitamin C.

The predicted vitamin C deficiencies (scurvy) have been indicated by reports of the State Bureau of Health and the State and Government Experiment Stations to be more prevalent and more acute than was even originally suspected.[7] To some extent scurvy and other classes of malnutrition may be alleviated by the temporary expedient of importing essential foods into the State, but the usual high price and the strangeness to the taste of imported, unfamiliar foods hinders the ready acceptance of outside supplies. This problem of malnutrition can be solved more fundamentally through an adjustment of the food-production program of the State so that those foods essential to the health of the inhabitants

[8] Stiebling, Hazel K. 1934. Food budgets for nutrition and production programs. Misc. Publ. No. 183 U.S.D.A., Washington, D. C.

are made available to all. The food habits, food storage, and food preparation methods must be built up from the crops of the region—provided *first* that the crops of the region are of the right kind to provide proper nutrition.[9]

Thus it will be seen first, that each nutritional deficiency disease requires the application of different techniques for correction, and second, that the mere discovery of the cause of a nutritional deficiency disease in terms of a vitamin or mineral does not necessarily bring about the elimination of that deficiency disease from any particular region. The chain of adjustments to an agricultural production program of a state and the correction of the habits of food preference and food cookery required to eliminate any one deficiency disease will be as hard sought as was the discovery of the specific deficiency agent which causes the trouble. Furthermore numerous facets of the corrective program impinge upon non-biological factors and require the coöperation of specialists in fields not as yet aware of the ramifications of malnutrition throughout the structure of society.

The prevention of malnutrition requires that a distinction be drawn between production for use and production for exchange, and though there are those who believe that the preventive will be sought only through an extension of the contemporary methods of production for exchange, critical evidence is here presented to show that to do so production for exchange must first be reoriented and placed upon a foundation in terms of production for use or need; otherwise the profit will avail them nothing and malnutrition remain with us.

(b) *The Contiguity to Superior Foods as Related to the Geographic Incidence of Malnutrition.* In order to determine the relative abundance of food production in different parts of the State, information has been accumulated since 1926 on the quantities of the principal foods produced in each of the 634 towns or plantations in terms of production rate per inhabitant. This evaluation of production in terms of consumer rate is a prerequisite to the study of needs in general. The consumption of a food such as milk, for instance, is likely to be higher in a region where

[9] Dove, W. Franklin. 1939. A Garden of Eden for Maine and the problem of malnutrition. Horticultural Meetings, Farm and Home Week. Orono, Maine. 23, March.

150 gallons of milk are produced per inhabitant than in a region where only ten gallons of milk are produced per inhabitant. Furthermore, deficiency diseases associated with low milk consumption could be predicted to exist in the low milk areas.

Furthermore, from a study of a large number of physical examinations of school children of the State, taken originally by town health officials for the purpose of the general school health program but reinterpreted here in terms of potential nutritional deficiencies, it is evident that *chronic general* malnutrition probably is more widespread than is any single *specific* deficiency disease. From the records on defects in Maine school children listed in Table 5, may be noted general malnutrition. Over 65 per cent of the children had one or more defects. Since several vitamins, A, C,

TABLE 5

*Defect Rate in Maine School Children**
1926 to 1934 inclusive

	Number of pupils examined	Number of pupils with defects	Per cent with defects
Defective teeth	94,989	39,904	42.0
Posture defects	12,243	909	7.4
Overweight	69,047	635	.9
Underweight	69,047	8,574	12.4
Any defect	15,672	10,247	65.4
Ratio of underweight to overweight			13.5 to 1

* Data calculated from original sources from towns scattered over the entire State. The above figures represent obvious cases for report to parents and are consequently lower than the values which might be secured for a nutritional study.

and D, and several important food minerals, Ca and P, are necessary for tooth and jaw development, defective teeth may serve also as an important sign of general malnutrition. Forty-two per cent of the children were reported for obvious teeth defects. From the table of defect rate one will observe also that underweight is fairly prevalent and that there are 13.5 children underweight to each child overweight. These characteristics of general malnutrition emphasize the need for a broad general adjustment directed toward their alleviation in addition to the special preventive measures required for each specific deficiency.

Specific deficiencies, as in a lack of vitamin C or of vitamin D

have their specific preventives, each of which calls for the development of a different type of agriculture to supply the specific lack or need. General or chronic malnutrition, on the other hand, requires a different mode of adjustment from each of the specific deficiencies, a mode of adjustment that is based upon widespread or far-reaching rearrangement in the entire system of food-getting starting from the production and ending with the preparation of food for the table. Anyone attempting to wipe out malnutrition will find that general or chronic malnutrition might be the last to go, perhaps because of its strong relation to non-biological, i.e., to economic and financial difficulties. However, if we set out first the most difficult part of the problem—general malnutrition—we may with its successful solution eliminate also a large number of the *specific* deficiencies.

A comparison between the contiguity of a region to superior foods and the relative incidence within that region of general malnutrition suggests a number of the adjustments required for the elimination of this greatest of afflictions. In Figure 45 is shown the areas of the State high per inhabitant, as contrasted to medium or low, in production of superior foods. The records are calculated by towns from an average of the first ten years' data, 1926 to 1934, with the data from the U. S. census dates 1925 and 1935 included for items not available in the State tax records or in State statistical reports. The foods included in the ratings were as follows: milk, eggs,[10] pork,[10] apples, strawberries, sweet corn, field corn, wheat, oats, potatoes, cabbage, and tomatoes. The foods, it will be noted, cover a wide range of nutrient supply, and if produced, distributed, and made available to the consumer in the proper quantities and qualities, these foods alone would go far toward the elimination of nutritional deficiencies.

When each town is rated according to the abundance per inhabitant of each food, and the ratings for all eleven foods are then grouped into one combined rating for each town, a map of the ratings will reveal areas of abundance in contrast to areas of non-abundance of essential foods. Out of ten possible rates, those rated 8, 9, and 10 (blue areas) represent areas of abundance. Towns rated 1, 2, 3, 4, and 5 (red areas) represent regions of non-

[10] By including milk and eggs, we automatically include beef and poultry.

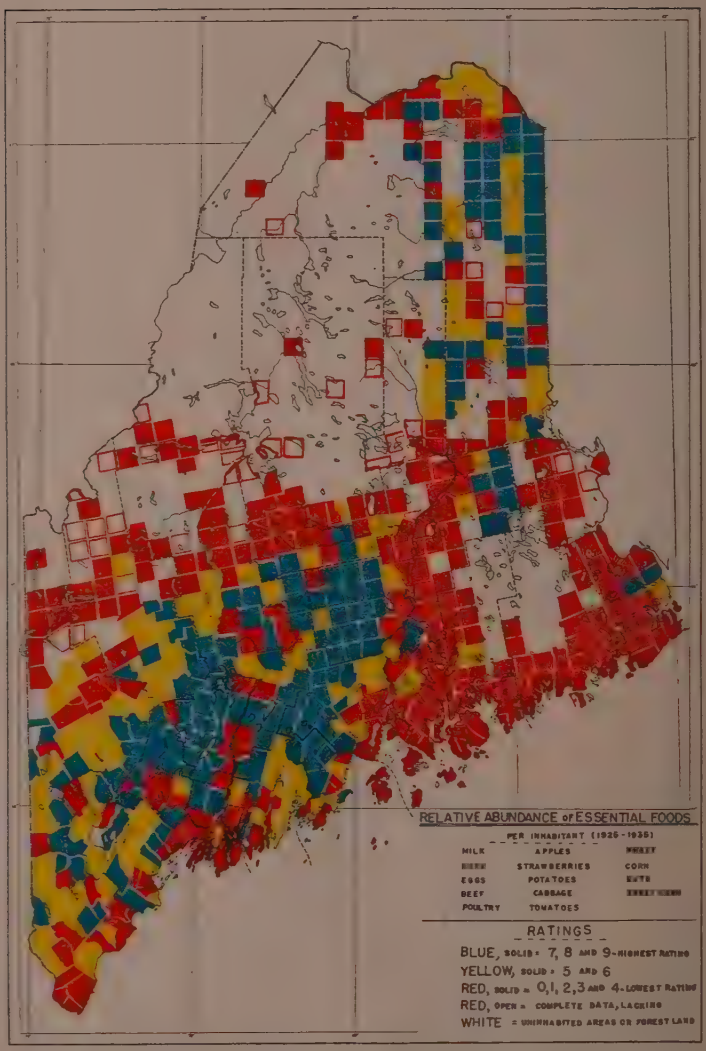


FIG. 45. Regional abundance of essential foods per inhabitant, 1925 to 1935. Ratings based upon: milk, pork, eggs, beef, poultry, apples, strawberries, potatoes, cabbage, tomatoes, wheat, corn, oats, sweet corn. Blue = 7, 8, and 9, highest rating; yellow = 5 and 6; red = 0, 1, 3, and 4, lowest rating; white = uninhabited or forest lands, or to places failing to supply complete data.

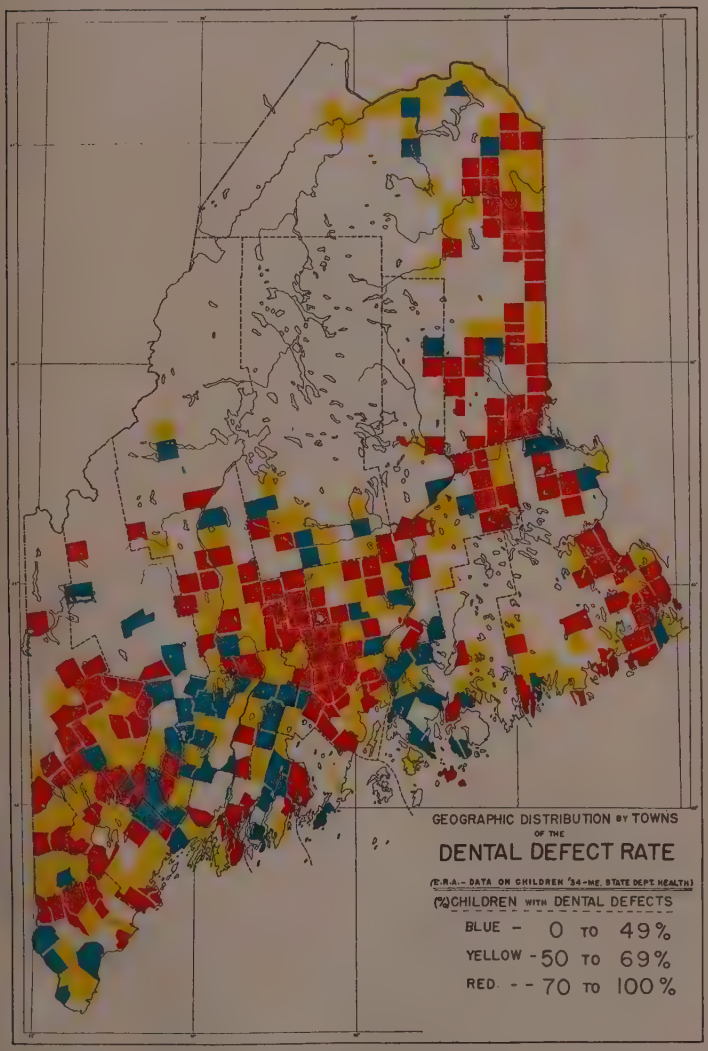

GEOGRAPHIC DISTRIBUTION BY TOWNS
OF THE
DENTAL DEFECT RATE
(E.R.A.- DATA ON CHILDREN '34-ME. STATE DEPT. HEALTH)
(%) CHILDREN WITH DENTAL DEFECTS
BLUE - 0 TO 49%
YELLOW - 50 TO 69%
RED - - 70 TO 100%

FIG. 46. Geographic distribution, by towns, of the dental defect rate, 1934 to 1935. (E.R.A. data on children 1934—Maine State Dept. Health). Red = 70 to 100 per cent; yellow = 50 to 69 per cent; blue = 0 to 49 per cent; white = unsettled or forest land, or to places failing to supply complete data.

abundance while 6 and 7 (yellow areas) are intermediate in food production.

AREAS OF HIGH FOOD-PRODUCTION RATE

According to Figure 45 there are four distinct areas in which these eleven foods are produced at the highest rate per inhabitant.

1. An area through the gardening section of York County in the southern tip of the State and near the markets of lower New England.
2. An area through the rich Kennebec County including the fertile valley of the Androscoggin to the Kennebec River.
3. An area in lower Penobscot County.
4. An area in the fertile Aroostook River Valley and the rich limestone areas of Aroostook County.

AREAS OF LOW OR AVERAGE FOOD-PRODUCTION RATE

According to the same Figure 45 there are several clearly defined areas rated as low in production per inhabitant for these eleven foods.

1. Western Maine, especially through the hilly regions of Oxford County.
2. The forest fringe which cuts through the center of the State east and west, through the forest fringe of lower Somerset and Piscataquis counties and central Penobscot County to form a circle around the forests of central Washington County which includes not only all of the inhabited area of Washington County, but also Hancock County and lower Aroostook County.
3. Another less well defined area along the rough coast lands from Cumberland to Hancock County, especially through the long-tilled regions of Waldo County.
4. The St. John River Valley.

From the distribution of low-production areas of the State one may predict that the St. John River Valley is not the only area where vitamin C deficiencies may appear. All of Washington County, Hancock County, and the forest fringe areas of central Maine would appear to be equally susceptible to these conditions.

In order, however, to compare this food contour map with the actual geographic distribution of nutritional deficiencies, there are several statewide surveys from which some valuable suggestive evidence may be secured. The results of a recent survey (E.R.A. 1934-1935. Me. State Dept. Health), in which the needs for dental attention among a selected portion of each community were ascertained, are plotted graphically in Figure 46. As indicated before, dental defects may stand as criteria for a number of deficiencies, perhaps even for general systemic malnutrition, in addition, to this instance, to economic and financial conditions.[11]

In this Figure 46 the *blue areas* represent towns in which less than 50 per cent of the children examined were in need of dental attention, *red areas* represent towns in which 70 to 100 per cent needed dental attention, while the *yellow areas* are in between the low and the high. Direct comparison in terms of color areas may be made then between Figure 45, representing food production areas, and Figure 46, representing one criterion of malnutrition.

Areas Rating Low in Dental Defects

The blue areas representing low rate of dental defects are reduced from the four areas noted for high-production of foods to only one distinct area—the region of the Androscoggin and west of the Kennebec Valley. The blue areas of York County, lower Penobscot, and central Aroostook have been reduced to a few scattered towns each. That Kennebec County should be the area of least need for dental attention as well as one of the best regions of production of a wide diversity of superior foods is evidence of a linkage between the two. The relationship may be direct through the food supply, or may be, in addition to this nutritional relation, indirect through financial ability to secure dental attention. Nevertheless the improved economic and financial conditions supposedly responsible for less need for dental attention may in turn be traced back to the balanced economy of the diversified agriculture upon a native fertile soil and to a wise balance with diversified industry.

Another area of the State, central Aroostook County, furnishes

[11] Dove, W. Franklin. Biological dentistry and health. Paper presented before Annual Meeting Maine Dental Assoc. 26 June, 1939. Bangor, Me.

interesting evidence of the working of several conflicting factors responsible for a high rate of need for dental attention. According to Figure 45 this region was in the blue, or high in the production rate of superior foods, but according to Figure 46 and in contrast to preliminary expectation, the needs for dental attention are highest. What are the modifying factors?

Direct effects:

1. This part of the State being farther north may receive less actinic rays from the sun.
2. The soil though calcareous in origin has been kept acid through the supposed necessity heretofore to control potato scab which otherwise attacks the potato, the specialty crop of the region. The requirements for an acid soil have also previously encouraged a rotation system of acid-soil crops.
3. The diversification of foods, even though indicated as obviously high for the State of Maine, may not be high enough even so for individual well-being. The very fact that it was necessary to consider figures up to 49.9 per cent in need of dental attention as in the blue is evidence enough that the food supply even in the best areas of the State is not adjusted to meet the needs of even the best regions.

Indirect effects:

1. The need for dental attention may, however, be associated more specifically with a lack of access to dentists, or a lack of financial ability to secure such attention. As stated previously in connection with the opposite condition in Kennebec County, there is much evidence that both indirect and direct effects may be traced back to a balanced economy. Though there is sufficient obvious reason to expect such a relationship to hold in a declining forest fringe such as that of central and southeastern Maine, there is no such obvious excuse for the existence of the same conditions in the fertile Aroostook River Valley. That a financial and economic factor does, however, enter into a causal relationship to dental defects may be inferred from recent evaluation on the financial status of this section of

the State. Here we find a debt of $28,000,000, or "about 55%of the total value of all farm real estate," [12] with the intensity of relief from 15 to 29.9 per cent—the second highest area in the country,[13] and with a rehabitation rate of over 150 clients per 1,000 farms—the highest rate in the country.[14]

In addition to this indirect economic and financial result of over-specialization in a crop that has suffered under the depression, there is also evidence of the lack of diversified agriculture in the amount of foods imported into the county.

Areas of High Dental Defect Rate

The areas of high dental defect rate shown in Figure 46 will be seen to correspond in nearly all instances with the regions of low food production. They include:

1. Western Maine, especially through the hilly region of Oxford County with extensions down into the northern half of York County, the oldest settled part of Maine, a region cultivated now for 300 years.
2. The entire forest fringe. This region, however, has expanded to include lower Penobscot County and has fused more completely with Waldo County.
3. Waldo County and the coast line.
4. The St. John area. This area has rated as medium for the need of dental attention in contrast to low for food production.

Since it is recognized that vitamin A affects the functioning of the enamel organ; that vitamin C affects the functioning of the odontoblasts of the dentine and the capillary activity of the gingival tissues; that vitamin D, calcium and phosphorus affect the function of both ameloblasts and odontoblasts; that fat and animal protein and even vegetarian diets have been shown to reduce the incidence

[12] Aroostook County Council 1936.

[13] Taylor, C. C., Wheeler, H. W., and Kirkpatrick, E. L., 1938. Disadvantaged classes in American Agriculture. Social Research Report No. VIII. Farm Security Admin, and Bur. Agr. Econ. U.S.D.A. Washington, D. C. April Fig. 26, p. 91.

[14] ——— Fig. 28, p. 100.

of dental caries, we may expect to find that the prevention of dental defects will rest in large part upon an adjustment of the food-production program to meet these nutritional needs.

Evidence is accumulating, however, that in order more effectively to plan a food-production program based upon need, we shall require a yearly, rapid, sampled, statewide nutritional survey combined with soil and plant evaluation,[15] not only for the purpose of detecting the incidence of each class of nutritional deficiency disease and setting up specific corrective measures implied as necessary for each deficiency disease, but also as a means of observing the year by year progress or lack of progress made by the corrective program thus far pursued. Production for exchange has its own forceful pressure groups for adjustment; production for use without a fair survey of needs from its own point of view remains mute.

Maine is endowed as few other states with a healthful climate and a variable soil adaptable to a wide variety of food crops necessary for abundant health. The State could be nearly self-sufficient with a few readjustments in its food-production program. From experiments by special techniques devised for the analysis of such problems, several potential modes of readjustment will now be considered in detail.

(c) *Specialization-Diversification Patterns of Needs and of Production to Meet the Needs.* Since each group of organisms and each group of individuals has its own peculiar environment, its own limited supply of natural resources, its own genetic and psychosocial composition, and its own characteristic reaction to all of these forces, each group has, therefore, its own definitive needs. Economic theorists may postulate a wider distribution of the goods of the world and nutritionists may realize the necessity for a more abundant supply of nutriment to all, but even when this fact of wider distribution and of greater abundance is accepted, nothing can be done about it until some *standard of requirements* has been established.

To raise the supplies to all individuals indiscriminately and without a guide brings in the danger of satiation, the desensitization of ability, the possible reduction in efficiency, or a shortening of

[15] Dove, W. Franklin. 1933. Prospectus for a coördinated research survey project on the causes of nutritional deficiency diseases in Maine. Dec.

productive life. Some standard of the needs of the group in terms of the biological effect upon the organism is required before the first move can be made to increase the supply of need-satisfactants to the group.

In search for a standard of optimum needs, a technique has been devised and described[16,17,18] whereby the needs of all individuals of the group have been compared one with another in terms of food preference and of rate of getting as judged by measurable biological values placed upon the individual. In search for this standard of optimum group needs, individuals were considered optimum or "superior" not only according to the extent to which they displayed a high rate of productivity (in this instance, a high rate of growth) but also according to the extent to which they were long-lived,[19] efficient in the use of food energy and consistent in their reaction. In brief, the results of numerous experiments, in which individual

TABLE 6

*Relation between Growth Rate and Mortality Rate**

Growth rate	Minimum	Sub-Average	Average	Aggridant	Maximum
Per cent of deaths within the group 0-11 weeks of age	5.6	1.4	0.7	0.4	2.5
Per cent to die at some time prior to 11 weeks of age	14.2	5.0	4.5	3.6	8.5

* The records are based upon five different experiments of fifty individuals per experiment in which groups of ten individuals (chicks) per group were permitted free access to the same foods. Individuals were shifted at 1, 3, 5, 7, 9 weeks of age into the five different classes representing the five different rates of growth. Individuals which grew at a rate between the mean and the maximum showed the lowest mortality rate.

[16] Dove, W. Franklin. 1935. A study of individuality in the nutritive instincts and of the causes and effects of variations in the selection of food. Amer. Nat. 69:476-486, 1935.

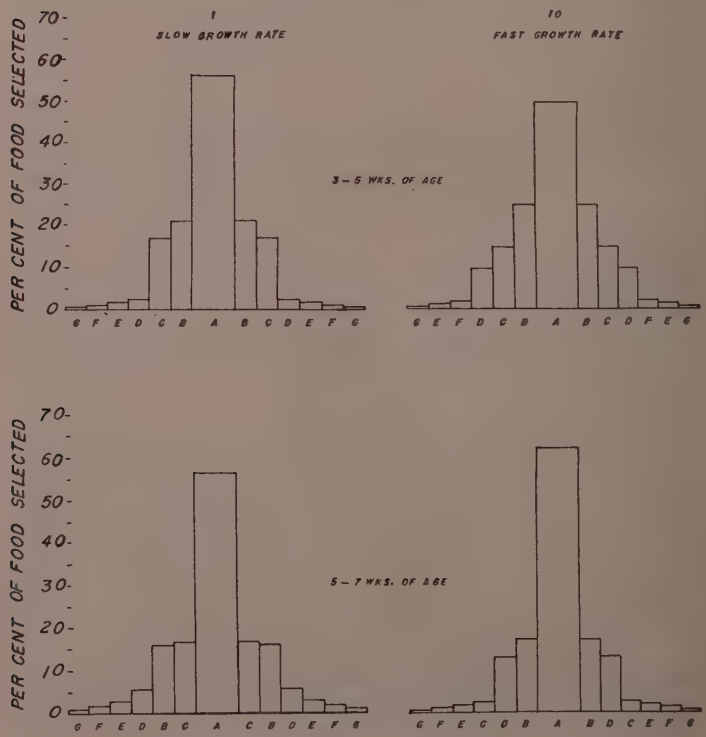
[17] ——— 1938. A study of individual versus group needs as a theoretical and an experimental approach to aggridascendance. Mtgs. of the Genetics Society of America, at Woods Hole, 3 Sept. Rev. Genetics 24:98, 1939.

[18] ——— 1939. The needs of superior individuals as guides to group ascendance: An experimental approach to the problem of "optimum" environment. Journal of Heredity 30:157-163, April.

[19] Additional data on the relation between growth rate and mortality rate are given in Table 6.

versus group getting during growth was studied show that the superior individuals of any single group are those which grow at a rate *above the average,* i.e., between the mean and the maximum. Once this fact is established we are able to work backwards to the food preferred and selected for this so-called superior (aggridant) rate of growth.

As was shown in the original experiments[16] (page 475, Table V) and summarized in the diagrams of Fig. 47 constructed from data in that report, one conclusion in particular stands out as important for the present discussion of specialization and diversification: That slow-growing individuals are more variable in their preference for different foods and tend to lack discrimination for different foods, while the fast-growing individuals tend to concen-


PER CENT OF FOOD SELECTED
70
60
50
40
30
20
10
0
1
SLOW GROWTH RATE
10
FAST GROWTH RATE
3 – 5 WKS. OF AGE
G F E D C B A B C D E F G
G E F D C B A B C D F E G
5 – 7 WKS. OF AGE
G F E D B C A C B D E F G
G F E C D B A B D C E F G

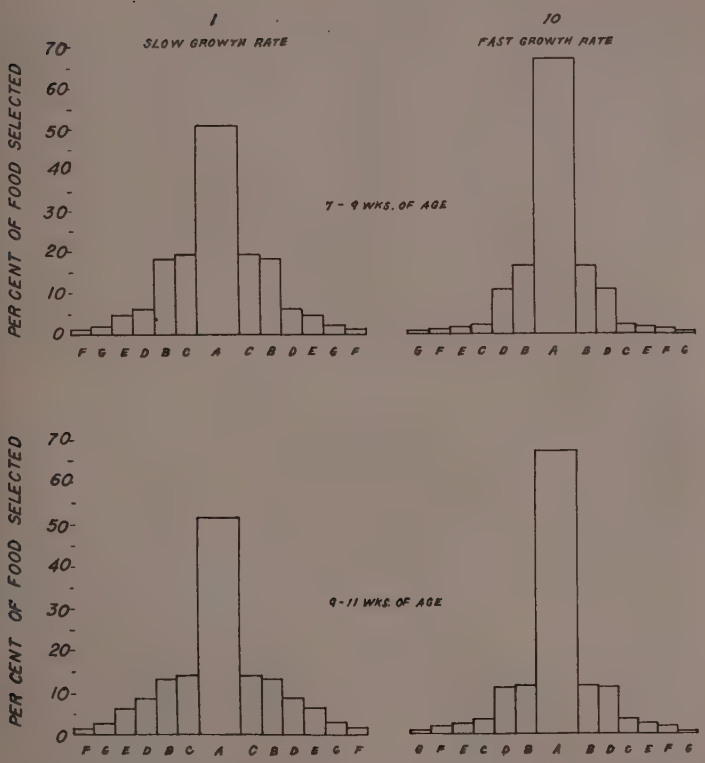


FIG. 47. Specialization-diversification patterns of food-getting and their relation to rate of growth.

The architectural pattern of food-getting varies with age, with the species and also with the rate of growth. After the first few weeks of maturation or of learning, slow-growing individuals continue to secure foods from a wide range, while the fast-growing individuals tend to concentrate their preferences to one or to a few of the different foods placed before them.

The failure of slow-growing individuals to develop an ability to discriminate between foods and the tendency on the part of fast-growing individuals to over-specialize in their selection of foods are equally conducive to malnutrition. In contrast to either of these extremes, the aggridant type shows in its getting a qualitative specialization-diversification pattern that is not so specialized as to be overbalanced, but is above the average in specialization with a definite ratio to diversification. (For original data see reference 16, page 487, Table V.)

trate their preference to one or a few of the different foods placed before them. In other words, slow-growing individuals have not fully appreciated food differences while fast-growing individuals have selected foods high in growth-promoting substances—such as protein and vitamins. During the first few weeks of maturation and learning, discrimination between foods is not so striking as it is later in the growth period. In the periods from 5 to 7, 7 to 9, and 9 to 11 weeks, individuals which grow at a maximum rate have exceeded all others in their preference for one food, i.e., ground corn, and have not distributed their preference for foods widely among the remaining foods. The resulting architecture of the pattern of food-getting varies with age, with the species, and also, as shown here, with the rate of growth.

The relation of the pattern of getting to growth rate is especially important when one wishes to apply theory to practice. In this differential selectivity one is able to discern one possible contributing cause for the failure of even these fast-growing individuals to be superior since the fast-growing individuals are as much overbalanced in their food selections as the slow-growing individuals are under-balanced. The fast-growing individuals have over-specialized while the slow-growing individuals have over-diversified.

Once this relation between the rate of getting and the specialization-diversification patterns is appreciated, one may observe also another characteristic of getting which may be used immediately in food production (as well as in other forms of need-satisfaction) and that is that the aggridant type shows in its getting a qualitative specialization-diversification pattern that is not so specialized as to be overbalanced, but is above the average in specialization with a definite ratio to diversification.

The foregoing conclusions have been secured from a study of individual versus group getting not only in experiments on foods but also in an analysis of individual town needs and town getting in comparison to their population growth rates or population declines. The principle, therefore, appears to be based upon behavioral characteristics common to living things regardless of whether machines, money, or food be the object of the getting.

The degree to which specialization is possible varies also with the combination of different need-satisfactants available. Out of more than a thousand experiments on three different species of ani-

mals, specialization has seldom risen above 65 per cent for any considerable period of time for groups of ten individuals. Specialization increases with advance in age, but, in the rat kept on experiment throughout its lifetime, specialization in any one food has exceeded in only a few cases, 85 per cent. Direct application of the results of these experiments to the food production program of the State may be made under the following conditions:[18]

1. The aggridant type is against both over-*E*xtension and over-*C*ontraction in numbers of different satisfactants. The positive values of food habits restrict unlimited excursions in food selection, but do not confine the repertoire to so few as to bring about deficiency diseases. Furthermore, the mechanics of food production is not favored by too wide a diversity nor by too narrow a range of different crops cultivated or of foods produced. There is, therefore, an E-C (Extension-Contraction) pattern of the aggridant.

2. The aggridant type, with an optimum number of different satisfactants supplied by the E-C pattern, is against the over-*S*pecialization of the maxima and equally opposed to the over-*D*iversification of the minima. The aggridant type indicates, within the limits of the environment, the S-D (specialization-diversification) patterns required for its own superiority as well as for the superiority of the group which will follow the lead of the aggridant.

3–4. The aggridant type draws a balance between (3) quantitative and (4) qualitative limits.

5. Bulky foods may be diluted in nutrient value to subminimal levels of requirement. On the other hand concentrated foods may bring about an overbalance or an excess of any one food fraction with which it is associated in metabolism.

6. Mechanical factors and the necessary order of acceptance also may interfere with or facilitate further need-getting.

From these six characteristics of the aggridant type one may plan a food-production program designed to have immediate value in the adjustment of any group to its environment.

The characteristics of the aggridant type are, however, so near in name to some other attempts to readjust agriculture, that special attention should be called to some of the important differences. The aggridant type, it was stated, is against over-specialization. On the other hand, the harm in over-specialization is not corrected by simple diversification. Cycles of diversification rise after each national

depression but soon fall as prosperity makes specialization again more attractive economically. In this cyclic vacillation food-production is following the profit motive rather than production for use: it is more profitable to diversify and "plant to prosper" during a national stagnation in the means of exchange,[20] and it is more profitable to specialize during times of rapid expansion. Furthermore, diversification is more likely to be forced upon the small producer at any time and at all times, perhaps, than on the large producer who has reserve resources to help continue specialization even through depressions. Waves of diversification, therefore, should not be looked upon as the result of a wise educational program of production for use, but as a search on the part of the producer for the greatest profit and while these two ambitions, profit and physiological need, may be more nearly one during periods of diversification, diversification in itself—as shown by the experiments in which the slowest were the more highly diversified—does not assure the consumer the optimum variety, quantity or quality of foods required for abundant health. Production for exchange and production for use spring from different sources, and have different ends in view; to bring about a fusion of the ends sought by each, we must bring about a fusion of courses.

The error of simple diversification may be recognized also in the rise of subsistence farming as a cure to over-specialization. Though subsistence farming is a trend in the right direction, i.e., toward a specialization-diversification pattern of the aggridant, nevertheless the quality of the foods supplied regionally under subsistence farming, as well as under diversified farming and forced through the profit motive alone, may actually *increase malnutrition*. As an example, diversified and subsistence farming may mean the increased production of native food and crops which are inferior nutritionally—such as *white* corn or *white* carrots—in place of the originally imported *yellow* varieties high in carotene (see Fig. 49A and 49B), or may encourage marginal farming on poor soil with its subsequent train of effects upon the plant and animal foods produced thereon.

From the foregoing brief analysis of some of the pitfalls to the

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[20] Kent, George. 1939. Dixie sweepstakes. Country Home Mag. 63(6):9, 45, 47. June. A description of the south's "plant to prosper" program.

successful elimination of malnutrition, one may recognize that the aggridant type merely stands as a guide to the research and production programs required for the elimination of deficiency diseases and for other similarly-determined maladjustments of society. The continuation of such work will be directed toward securing aggridant soils and aggridant food crops so as to ensure a specialization-diversification pattern of need-satisfactants for rate of development when aggridant implies, by definition, recourse by all individuals of the group to the physiological needs required in the particular environment for the support of a high rate of productivity, longevity, efficiency in the utilization of energy, consistency, and any other valued characteristics belonging to the individual and to the group of which he is an integrated part.

In the foregoing paragraphs a few possible misapplications of simple diversification have been considered. In addition to specified diversification, the aggridant type also indicated the necessity for a fairly high degree of specialization which, in turn, when misinterpreted or when allowed to follow the profit motive alone without regard for production for use, may actually encourage malnutrition.

As one example of a number of instances of potential misdirected specialization which may contribute to and encourage, rather than discourage, general malnutrition, the trend in production of eggs is presented, as compared to the needs for this commodity in the State of Maine.

According to the census records of 1930 and 1935, an average of 205 eggs was produced per inhabitant of the State. Without the shipment out of the State or sale to summer visitors this quantity would barely supply the needs of the inhabitants for a moderate diet and would fall far below the 360 required for a liberal diet.[8] Large shipments, moreover, are made to southern New England markets and to recreation centers of the State. In fact, in some large sections of the State where production is confined more to local markets, as in part of Washington County and in Aroostook, only 127 to 143 eggs per inhabitant are produced annually. Thus there is indicated, according to the needs, an increase in production to meet both market and home consumer. The method by which this increase should be secured raises a problem in the economics of food production.

In Table 7 the changes in this industry from 1930 to 1935 may be noted as follows: The number of eggs produced from *small* farm

flocks, i.e., flocks with less than 200 birds, *decreased* during this five years by 21.7 per cent, while the number of eggs from *large* flocks *increased* by 19.9 per cent. Those going out of business showed an increased egg production of 21.7 per cent. These figures, therefore, show the existence of a trend away from the wide distribution of egg production for immediate use, to large scale production for exchange from large specialty flocks. Eggs from birds in large flocks 1,000 to 2,499 in number increased by 121.4 per cent and yet the total number of eggs produced on all farms decreased by 6.5 per cent during the same five years. A concentration of the egg-production business into larger flocks may appear to contribute toward efficiency. In this instance, however, efficiency may be short-lived due to the uncertain conditions surrounding the support of the industry in this particular region. The reasons for this statement follow.

TABLE 7

*Specialization-Diversification Patterns of Food Production Trend in Production of Eggs in Maine 1929 to 1934**

Size of flock 3 mo. +	Farm reporting 1934	Dozens of chicken eggs produced		Trend 1929-1934	Per cent change 1929-1934	Per cent change 1929-1934
		1929	1934			
None	416	129,199	157,296	↗	+21.7	
Under 50	19,012	4,283,878	3,476,099	↘	—18.9	
50 to 99	3,324	2,307,680	1,712,118	↘	—25.8	—21.7
100 to 199	1,510	2,133,278	1,643,799	↘	—22.9	
200 to 399	824	1,970,749	1,932,118	↘	— 2.0	
400 to 699	359	1,437,715	1,607,318	↗	+11.8	
700 to 999	99	688,382	757,535	↗	+10.0	+19.9
1,000 to 2,499	110	593,485	1,313,769	↗	+121.4	
2,500 and over	6	193,211	243,966	↗	+26.3	
State Total	25,660	13,737,577	12,844,018		—6.5	

* Data from Special Report Bureau of Census, U. S. Dept. of Commerce, Washington, D. C. 1939.

The feeding of birds for high production in large flocks requires large supplies of grains and concentrated feeds. Today these feeds are largely imported from the West at expensive rates. In 1924, grain to the value of $11,907,509 was imported into Maine[22] chiefly for poultry and dairy cattle feeding. When prices are low

[22] Merchant, Charles H. 1927. Maine Agriculture. A statistical presentation. Maine Agr. Exp. Sta. Bul. 338:148.

or subsidized at definite levels, the stimulus is given for over-expansion in large-scale production. But when the price of these imported foodstuffs rises, as it did in 1916, or when the price of eggs falls below a certain ratio to the price of grain, there is a widespread scramble to get out of the business. This type of agriculture is therefore not permanent, while vacillation in the supply of eggs to the consumer—one of his essential foods—encourages undernutrition of the consuming group.

Furthermore, this type of over-expansion also is made when Western eggs are being imported into the State and sold in the same markets at prices ranging from 10 to 30 per cent lower than native eggs. As far as the consumer is concerned, with each new research on storage and handling the Western fresh egg is approaching the native fresh egg in consumer preference, while the greater cheapness in cost of the Western produce will make possible a shift by the consumer from a restricted diet to an adequate diet for this one item of food.

The pursuance of such methods of producing important food supplies represents not only an unstable agriculture and a cause for the vacillation in foods required for the prevention of malnutrition, but represents also the source of much of the discontent within the industry with their frequent plea for assistance against deficiency diseases produced by forcing rations; against bacterial diseases, the by-product of forced growth, forced production, and over crowding; and against variable imported food supplies.

These economically determined causes of biological maladjustment must be eliminated, not by the genetic selection of superior germplasm to withstand the conditions, not by the specialized histological or pathological analysis of each disease or deficiency disease, but rather by adjustments in the primary causal agent whether that causal agent be economic or biologic. [23]

The elimination of a large part of the foregoing internal difficulties, together with a broadening of the food supplies required to meet the needs of the consumer, will be secured through a trend *opposite* to that now taking place in this industry, used as an example, i.e., a trend directed toward a more widespread distribution of the farm-sized flocks and herds, the farm itself then supplying a

[23] Dove, W. Franklin. 1938. Not by genes alone. Genetics Society of America, Richmond, Va. 29 Dec. Abstr. in Genetics 24:69. Jan., 1939.

large part of the ration as home-grown foods. To bring about such a development, the available supplies of proteins and grains have been analyzed nutritionally, but one finds necessary further nutritional evaluation and genetic selections before the livestock of the State can be supported at high levels of production upon native products. Some of the requirements of evaluating food crops in terms of needs will be referred to again in section (f).

The mode of adjustment indicated from observation on the needs of the aggridant and the means required to supply those needs implies a decrease in the over-specialization indulged in, not alone in this one industry but in several other industries of the State. Reference has been made already in Table 4 to the food crop industries of the State in which the production of potatoes far outbalances the production of other vegetables and fruits. In these latter crops a subnormal productive level is already strongly evident from the incidence of vitamin C and other deficiency diseases. Other town industries, such as pulp and paper, cotton, woolen, and shoe manufacturing concerned with the production of needs but monopolizing the town resources of labor, timber and water power, produce in the town conditions similar to those in the over-specialized organism. It must be recognized that the balance between industries of the town producing goods from the mills and industries of the field raising food must form a pattern of use for the entire group consistent with the needs of the aggridant town.[21]

The corrective suggested, moreover, should specify a diversification to retain the *large* producer of goods, who as usually immune from programs of diversification, as well as the *small* producer who usually has already through necessity complied in part. It should specify also an increase in specialization by those who now too widely diversify for the purpose of stabilizing an efficient trade market. Furthermore, the specialization-diversification pattern of the aggridant should be based upon facts measured in terms of the degree to which each unit of the pattern supplies a true need. A true corrective requires more than an economic adjustment, it requires a bioeconomic control.

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[21] Dove, W. Freudin. The Needs of Superior Individuals as Guides to Group Ascendance. II. Population changes in relation to need-satisfactions: maximums and patterns of the needs of the aggridant. In press.

The producer should not be the sole concern in food-production research programs for adjustment: the consumer should not be taxed for benefits not received. Landlord-tenant agreements whereby diversification is extended by the landlord to cover the tenants' family needs[20] do not supply the non-agrarian consumer with his needs. Only by reaching beyond the producer and the producer's agents to the consumer through a bioeconomic fusion of production for use with production for exchange will the proper adjustment be attained.

From the foregoing considerations on the methods of adjustment indicated by superior or aggridant individuals, one may recognize the trend as an attempt on the part of the group as a whole to return to the balance sought by the organism as a whole. The parallel, it must be stated, is true only in part: to the extent that greater balance is sought. A striking difference must be recognized: that in the uniqueness derived from individual differences and accumulated in an expression termed the aggridant type, the qualitative specialization-diversification pattern of needs of the aggridant indicates in addition to the mode of adjustment, both genetically and environmentally determined, the direction to be taken by the group in their search for needs required for group progress.

(d) *The Evaluation of Foods in Terms of the Nutritional Needs of Superior Individuals of the Aggridant Type.* The conventional scientific method is to evaluate foods nutritionally by procedures which measure separately the quantity and quality of constituents known to be required by the organism for growth and development or for any vital function. Generally the evaluations are made by additions and subtractions of those fractions of the mixed diet or ration to be tested. The procedure then is to feed the ration or diet containing or lacking the unknown fraction to an experimental animal or plant, and, according to its response, to give the added or subtracted fraction a value.

This method of measuring the nutrient value of foods, fraction by fraction, and finally determining the food needs of the species from a summation of the parts tested forms the technical structure of modern nutritional scientific method.

[20] U. S. Extension Service. 1939. Landlord-tenant cooperation in South Carolina gets encouraging results. Ext. Serv. Rev. 10: 4: 58-59. April. Extension Service, U.S.D.A., Washington, D. C.

Once the unknown fraction has been broken down sufficiently into its parts and isolated in relatively pure form, and once the chemical formula has been ascertained, that part of the procedure in which the organism is asked for an answer may, from then on, be dispensed with except for the occasional return to the organism for verification of results or for reassurance that the correct values are being attributed to each food fraction.

With this procedure in mind, one may recognize that animals, particularly the higher animals and domestic livestock, and most particularly man, follow in their natural environment methods of food-getting which are not included in the technical procedures of food evaluation indicated above. Since the results of evaluations of foods must be transferred in the end from the laboratory into practice, the necessity arises for a revaluation of the values secured in the laboratory. Furthermore, the values secured in the laboratory have not taken into consideration the genetic variability of the species to be fed, except to see that fair samples of the group are used for the tests. These samples, of course, if taken at random represent the average of the group and leave one in doubt as to the efficacy of applying *average* need-values to the entire group.[26] This doubt is especially important when we realize that upon this point revolves the difficulty of establishing the standard for needs to be supplied to the group. Since the conclusions secured on the correct standard for nutritional needs may supply indications for those concerned with the distribution of other goods than food, we may find in the determination of a standard of needs a system of evaluation applicable to a wide range of need-getting.

The standard of needs, for nutrition, as secured by various workers with different methods appears to reaffirm a *high* rate of

[26] A recognition of the fallacy in the concept of averages formed one of the incentives for the development of the individuated technique as described in Amer. Nat. 69:476-481, 1935. Stanley D. Dodge has also recognized the fallacy of averages for climatology, geography, and ecology, and questions the value of climatic maps in terms of isotherms, isohyets, and isobars. Dodge suggests studies in terms of variables, as extremes or as landscapes (Science 87:85, 28 Jan. 1938). As a basis for the subject "Individual differences in animal psychology as points of departure for research," Calvin P. Stone recognizes the same fallacy in the use of averages (Retiring Address of Vice President, Psychology Section A.A.A.S., Richmond, Va., Dec. 1938), as does K. Dunlap in "The Average Animal," Jour. Comp. Psychol. 18:1-4, 1935.

need supply as essential to a long, productive life—even though there is some evidence that slow growth rate is associated with longevity.[27,28] On the other hand, the results of Robertson and Ray in 1920 and the experiments by Sherman and Campbell (1924 to 1937) have been summed up recently by McCollum, Orent-Keiles, and Day, as follows:

> Animals (mice) which grow rapidly live a longer time than slowly growing animals (mice).
>
> The evidence at present suggests indubitably that general well-being and healthful longevity are promoted, not by food restriction during youth, but by the generous provision of a well-balanced diet.[29]

Experiments carried on in this laboratory[16,17,18] are in agreement in part with the conclusion that a slow rate of growth is not conducive to long life. These experiments, moreover, were carried out on groups of individuals varying serially in growth rate from slowest to fastest with an interpretation of growth rate, as stated before, in terms of longevity, efficiency, and consistency. That nutritional needs must find expression in such values as these has been recognized, but they have not been accurately measured. That such values or standards are now being considered as important in the evaluation of foods and standards is shown by the following recent editorial review of the subject:

> Investigators of gross efficiency of transformation of energy matter cannot overlook possible factors affecting longevity and fertility because they enter into the reckoning of long-range efficiency. From the long-range viewpoint, it seems very important to pose such questions as: (1) Is extraordinary rapid growth, or high productive level of any kind, brought about by dietary or/and hormonal methods compatible with maximum longevity and fertility? (2) What is the relation between successive increments of productive stimuli (e.g., successively larger administrations of dietary and hormonal factors) on longevity, fertility and long-range gross effi-

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[27] McCay and Crowell. 1934. Prolonging the life span. Scientific Monthly 39:405.

[28] Asdell and Crowell. 1935. Effect of retarded growth upon sexual development of rats. Jour. of Nutrition 10:13.

[29] McCollum, E. D., Elsa Orent-Keiles, and Harry G. Day. 1939. The newer knowledge of nutrition. Fifth edition. New York: The Macmillan Co., p. 637.

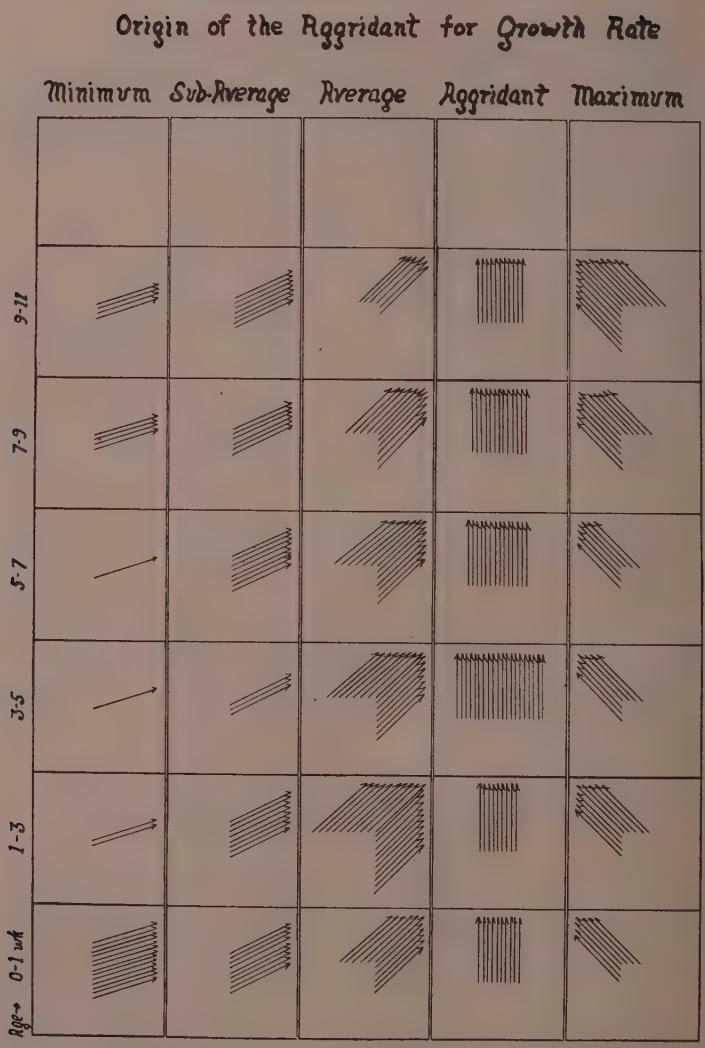


FIG. 48. Shifts in rate of growth made by the aggridant type. An example of the shift in growth rate of fifty individuals which have grown during one or more of the seven periods, at a rate between the mean and the maximum. For growth rate, these aggridant individuals represent the standard for the group both for the evaluation of nutritional differences between different varieties of foods or combinations of foods and for the derivation of specialization-diversification patterns of production in terms of need-satisfactants.

ciency as contrasted to immediate productivity and efficiency? (3) May not the price paid for immediate success in achieving relatively high levels of productivity and gross efficiency be offset by unfavorable after effects with possible long-range failure?

There is need for investigating the influence of accelerated growth and other productivities as results of special dietaries and hormonic factors not only on immediate efficiency but also on long-range efficiency which must be compatible with longevity, "highest livability," and fertility.[30]

We must recognize, however, that to establish a standard based upon some such values as those indicated and used in the present experiments requires the development of a technic which evaluates tendencies of *all* individuals of the group in terms of a *type* which best represents the composite preference of all members of the group. Since the aggridant type has been established under these conditions and since the aggridant also meets the requirements of a high rate of growth, we may now take the next step in the application of the theory of aggrid ascendance to practice: the evaluation of different varieties of foods in terms of their ability to supply nutrients required for aggridant growth rate.

Prior to the presentation of an example of this method of evaluating foods, some of the shortcomings and some of the points of superiority of this method of food assay over the conventional bio-assay will be briefly listed:

Advantages of the Individuated Appetitive Bio-Assay Technic Over the Conventional Bio-Assay

The appetitive method of experimentation is too young for predictions as to its ultimate merits. The method used and exemplified again here in the bio-assay of foods is based not only upon appetite or preference made by the group but also upon differences between the preferences of individuals within the group. The recognition of individual differences in the appetite, in the preference or in the getting makes possible a parallel analysis of social and economic phenomenon of getting which is frequently closely

[30] Brody, S. 1939. Factors influencing the apparent energetic efficiency of productive processes in farm animals. Jour. of Nutrition 17:246-248, March.

associated with its biological equivalent. Furthermore, the recognition of individual differences in preferences makes possible the determination of optimum needs and the determination of the difference between need and greed—values which the group would reduce to averages and thereby make impossible a differentiation between need and greed.

However, the use of the appetite method without recourse to individual differences has recently, even in terms of the group, produced interesting results in the analysis of the function of the endocrine glands and of pathological conditions. There has been shown to exist, for instance, by the group appetite method, an intimate relation between adrenal glands and the metabolism of sodium—Curt P. Richter and John F. Eckert, Endocrinology 22:2:214-224, 1938; between the parathyroid glands and calcium, Curt P. Richter and John F. Eckert, Endocrinology pp. 50-54, Jan. 1937; and between diabetes insipidis and an abnormal metabolism of sodium chloride, H. G. Swann, Science 90: 67-68, 1939.

Groups of individuals may be used also to advantage in appetite experiments without distinction as to individual differences in appetite, at least for the first stages in the analysis of the problems. Especially is this true in the analysis of pathological conditions or in the study of restricted diets (as shown in the example in this section). In these instances nearly all individuals of the group, and therefore the group as a whole, will show the effects of the pathological condition or of the restricted field of food selection by a group-alteration in bodily reaction.

When the analysis is made, on the other hand, in terms of the individual, many new difficulties are injected into the problem. Thus, individual differences may not be clearly distinguished: the group as a whole may thrive or suffer together. Such results are to be expected if the food sources are restricted (or the obverse)—restrictions which deprive even the wisest or most fortunate individual of the needs required for the expression of his biological superiority. And again, some observers are confused when the majority of individuals of a group select the wrong food and prefer to subsist on a known deficient diet.[31] Here again, the manner of conducting the experiments together with the possibility that

[31] Wilder, C. E. 1937. Selection of Rachitic and Anti-Rachitic Diets in the Rat. Jour. Comp. Psychol. 24:3:547-577.

nature has not endowed the animal with an ability to distinguish the artificial element added to the deficient diet, even though that artificial element be a corrective of needs, may cause the experimental animal to select his food according to some other dominant characteristic of the food of less value to him nutritionally.

Most of these difficulties for our purposes are obviated by the change in point of view from cause to effect, that is, by a classification of food-seeking individuals in terms of the end-result, in terms of those characteristics considered by the experimenter as of value in an organism, without regard, at the present time, for the causative factors responsible for the observed end-results.

With this distinction in point of view in mind, the advantages of the individuated appetitive bio-assay technique may be listed briefly as follows: (1) Individual differences are recognized, and the individuals which best represent the group in terms of high productive rate, longevity, efficiency in the use of foods and consistency in reaction (the Aggridant type) stand as guides to the needs of the group. (2) Consideration is given to the effect upon food consumption of psycho-social factors—of imitation, greed or social facilitation and other individual-group relations occurring freely in nature and affecting need-getting to a high degree, yet not measured in the technics of the conventional bio-assay. (3) The positive physiological effects of food combinations are taken advantage of by the aggridant immediately since the favorable combinations—if such exist—will be reflected in the aggridant. The conventional bio-assay technique may, for long periods of time, miss the interactive and combination values of different nutrients and food fractions. (4) The technique based as it is upon a free selection of nutrients with freedom among the selectors—makes possible, by various degrees of mixing and combining, the discovery of the optimum type and degree of freedom in both foods and selectors. The continual resort to a free selection of food by the human being, by all wild life and to a large extent by domestic animals enhances the necessity for a provision in the technique whereby the value of various degrees of freedom in selecting different foods may be measured. (5) The method automatically combines *genetic* with *environmental* determiners of needs by sorting out as guides only the superior regardless of the origin of that superiority whether it be from genetic factors, from internal physiological factors, from environmental factors, from the effects of learning and condition-

ing, or even from chance. (6) The individuated technique implies an evaluation of needs within the limits first of some stated environment. In this dependence upon environment the technic makes possible a regional interpretation of scientific fact. For instance, calcium deficiencies would be slow in attracting scientific attention in a region of available limestone and virgin soil. The science of the northern forest-fringe must inevitably evolve a regional science distinct from that of a tropical island. Conversely the results of such experiments carried on upon the tropical island cannot be verified in full in the northern forest-fringe and this is disturbing and raises doubts and mistrust, at least in the minds of those who consider science as a creator of laws that should be evident in all environments.

DISADVANTAGES OF THE INDIVIDUATED BIO-ASSAY TECHNIC

(1) The chief disadvantage, so-called, to the individuated bio-assay technic lies in the fact that in cutting across from foods preferred to the final result—the aggridant—and working backwards to the pattern of foods which brought about that final result, the *specific* agents responsible for the results are not indicated. The supposed lack or defect in the technique may at first disturb those accustomed to the interpretation of nutrition in specific terms of vitamin, amino acid, or other food fraction. But the method itself should not be criticized for this apparent present lack, since the causes behind the production of the aggridant may be resolved into specific terms at any later time prior to which time the results may already have been applied to practice, long before the specific causes are established. (2) Another disadvantage, so-called, appears in the fact that the aggridant type represents the accumulated result of too many unresolved forces and may be interpreted, by comparison with over-specialized techniques, as too generalized. This defect is apparent only to those who are determined to keep science restricted to either the inductive or the deductive method. A true science of the organism or of society must regard both methods.

In brief, the two methods of analysis, the individuated bio-assay technique and the conventional bio-assay technique should work together, the individuated technique feels the way and jumps the ravines ahead of the group, while the conventional specific assay

method spikes the results, gives a "reason" for the cause of the differences and constructs a bridge over the ravine. Furthermore, the technique of individuated assay requires little if any costly technical equipment. It starts with the methods and equipment with which Adam might have worked and is, therefore, suited to primitive exploration. In undeveloped regions as yet unendowed with either the spirit or the financial requirements for the conventional methods of science, this individuated technique serves as one means of gaining fundamental information in the face of forces which might otherwise cramp research into the one so-called "practical" channel, which serves production for exchange without regard for use. As another point of difference, and even more important, the individuated technique will indicate, by its advance position ahead of the group, which ravine is worth bridging. In this characteristic, the aggridant guides research, though later it comes to take from the results of the conventional methods new materials on which to go farther ahead. Thus the aggridant automatically eliminates much of the trial and erorr of the specialized scientific method—of the scientific engineers who alone and unguided by the aggridant may and do build bridges over a number of useless ravines in their search for the right way. The aggridant type, by indicating immediately the crude needs required for its own superiority, and the biochemical assayer, by searching out the cause of the superiority, direct and construct the means of adjustment and the manner whereby the group may progress.

Food Pattern and Growth: The Effect of Varietal Differences in One of Seven Foods

Consideration may be given now to an example of the contributions peculiar to the individuated technic. The usual variety of sweet corn grown in Maine represents one of those fortunate chance selections of a yellow-kerneled variety now known to be high in vitamin A. Not all parts of the country are so fortunate—fortunate because of the difficulty to root out a variety from a people, once that variety has grown into the habits of those who raise and consume the product. Although Maine's sweet corn is largely of the varieties high in vitamin A, there are still some varieties of white sweet corn as well as white field corn favored by some sections of the State. Furthermore, because of the faster rate of ma-

turity and consequent higher yield[32] of some of the white varieties of corn, or those of mixed white and yellow, there is a continual temptation to import new white varieties and expand the area of white variety production. This fact is important, if one recognizes the possible relation of white sweet corn and white field corn to vitamin deficiencies in the consumer within these regions. An increase in subsistence farming and an extension of plant breeding must be made with regard for the qualitative facets of the food production pattern of the aggridant.

By following the food preferences of the aggridant, five foods and two mineral supplies have been secured which together bring about normal biological functioning. These seven foods presented to the laboratory white rat for free selection have made possible normal growth, maturity, reproduction, lactation and normal length of life throughout many generations. The number of different foods, it will be noticed, has been confined to an E-C pattern so that each food supplies some one or more essential. If large numbers of different satisfactants had been used, duplication in contribution would interfere with the results and make impossible the testing of one food against another. These seven foods, then, may serve as a standard of comparison, and varieties of foods exchanged for any one of the standard may be tested by the positive or negative effect the exchange of one food for another produces upon the aggridant.

Thus, for instance, if the seven foods, yellow attrition *corn,* dehydrated *meat,* ground whole grain *wheat* and *oats,* dehydrated skim *milk,* ground *oyster shell* flour and *bone* flour are presented for free selection to fifty day-old chicks, growth curves are secured up to eleven weeks of age as shown in Fig. 49A. If now one replaces only one of the foods, *yellow attrition corn,* with *Aroostook white attrition sweet corn,* and presents these foods in the same manner as before to another group of day-old chicks, a striking difference is observed in the effect upon growth, as shown in Fig. 49B. Growth, in fact, was scarcely possible by the exchange of the *white* for the *yellow* sweet corn. No animal lived beyond four weeks of age with white sweet corn as one of the seven foods; not even the individual nutritionally wisest could make a selection of foods (Fig. 50B) and yet the difference between the two oppor-

[32] Field corn variety trials. Me. Agr. Exp. Sta. Bul. 391:261, 1938.

tunities consisted only in the simple exchange of one variety for another of the same food.

Although differences in nutritive value between white and yellow corn have been known to nutritionists for decades, this material was used as an example in order to show the magnitude of the effect of differences between varieties of a single food, which differences still tend to be considered unimportant by those responsible for the nation's food supply. Whatever ability human beings may have had to select foods, it has been misdirected under the impetus of production for exchange in which the variety of heaviest yield or the variety of highest market appeal, regardless of nutritive value, has come to gain the producers' preference and the market display space. Too frequently these high-producing varieties are diluted or are low in nutritive value and produce a temporary prosperity of production for exchange at the expense of good nutrition.

The results of years of testing potential sources of foods of the State have impressed upon us the futility of increased expansion of subsistence farming or of more diversification of farming as a means of decreasing the high incidence of deficiency diseases, unless new varieties of crops are brought into the State. For the human diet new vitamin A, B and C foods are needed and are being sought and tested. For livestock vitamin A, D, and G foods are required and, as will be noted below, have been partially secured. Until these foods are secured at home, supplies from outside the State must be imported. But the present necessity for importation acts as so much of a depressant upon getting an adequate regional supply that the final solution waits upon the incorporation of the nutritional point of view into the plant breeder's program.

In the search for vitamin A, D, and G foods for livestock, work has been directed toward improving the products of the Maine seacoast fisheries, since it was early found that these foods were high at least in vitamin D.[5] In coöperation with the companies producing these foods, attention has been directed to increasing the vitamin A and other nutritional values of the product. This has been accomplished through an attempt to bring back all possible parts of the fish into the original whole. Furthermore, improvement in the methods of dehydrating the fish by the companies interested in conserving sea food now prevent loss of water-soluble elements. The resulting dehydrated product should compare favorably as to

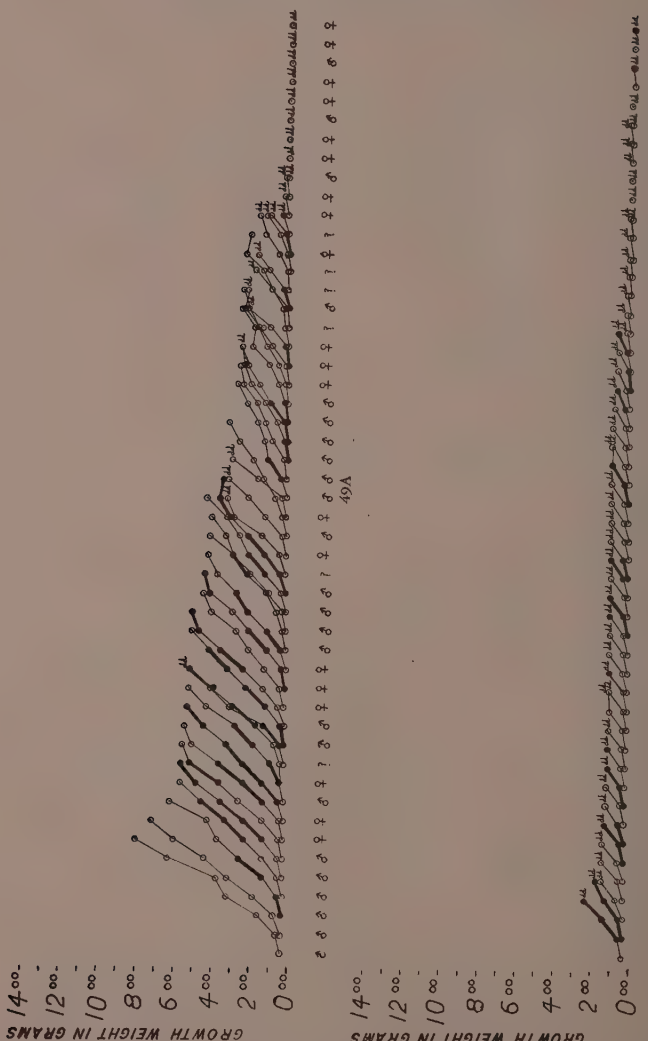


FIG. 49A and 49B. The evaluation of differences between varieties of the same food crop on the basis of individual preference. The fifty chicks in group 49A had free access to the following foods: attrition yellow corn, wheat, oats, dehydrated meat and milk, oyster shell, and bone flour. The fifty individuals in 49B had access to the same foods with the exception that the yellow corn was substituted by Aroostook Early White sweet corn. The first group of foods for 49A with yellow corn was not of the correct variety to bring about exceptional growth, but the simple substitution by the white sweet corn reduced the poor growth rate to a high death rate.

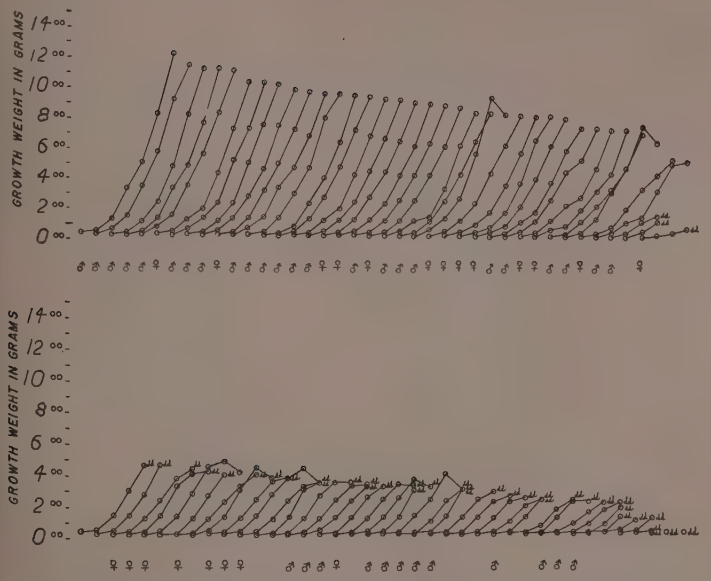


FIG. 50A and 50B. The comparative nutritional value of varieties of food crops fed according to the preferences of the aggridant type. The thirty-eight individuals listed in Fig. 50A consumed the foods selected by the aggridant shown by heavy lines in Fig. 49A.

Figure 50B consumed foods dictated by the aggridant of Figure 49B. A more satisfactory growth rate is secured from these foods fed as mixtures than from the same foods fed free. Nevertheless, the difference in value of yellow corn (Fig. 50A) over this particular variety of white corn (Fig. 50B) is still obvious from the differences in growth curves and in mortality rates.

vitamin and mineral content and purity with the canned product sold on the market, or with the same products retrieved from the Japanese fisheries by the Imperial Government Institute of Nutrition and sent as croquettes to the Japanese army of occupation in China.

Years ago, at the beginning of these experiments, not much vitamin A could be detected in this Maine dehydrated fish and results similar to those shown in Fig. 49B were secured when some varieties of dehydrated fish replaced the dehydrated meat. Today, the replacement of the meat by dehydrated fish shows a remarkable difference between the two foods—especially when complementing

FIG. 51A and 51B. The evaluation of differences between animal proteins on the basis of individual preference.

According to Figure 49A and 49B yellow corn is superior to white corn. In Figure 51A, the same seven foods were used with the exception that the dehydrated meat was exchanged in these instances with dehydrated fish from the Maine coast. The substitution of one animal protein for another produced in this instance a marked difference in growth response in favor of the dehydrated fish. Even when the poorer variety of corn was used—the white sweet—a fairly high rate of growth was secured (Fig. 51B).

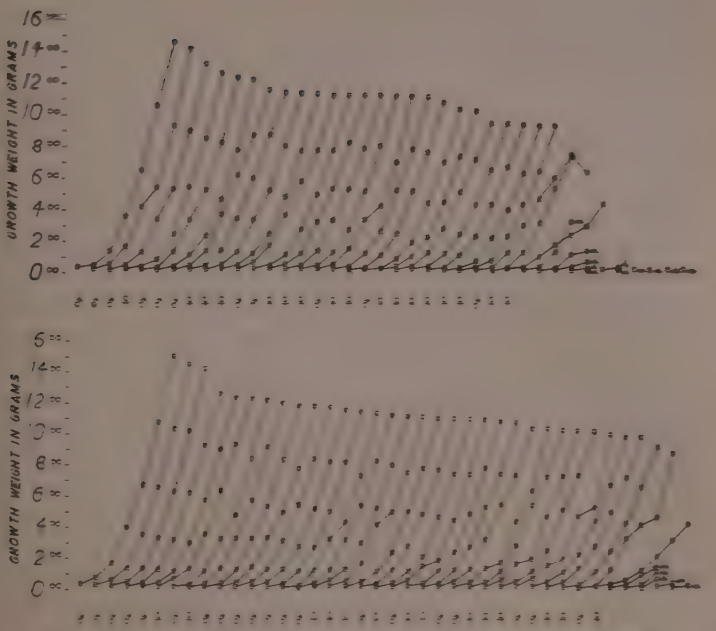


FIG. 52A and 52B. The comparative nutritional value of two different animal proteins fed according to the preferences of the aggridant types.

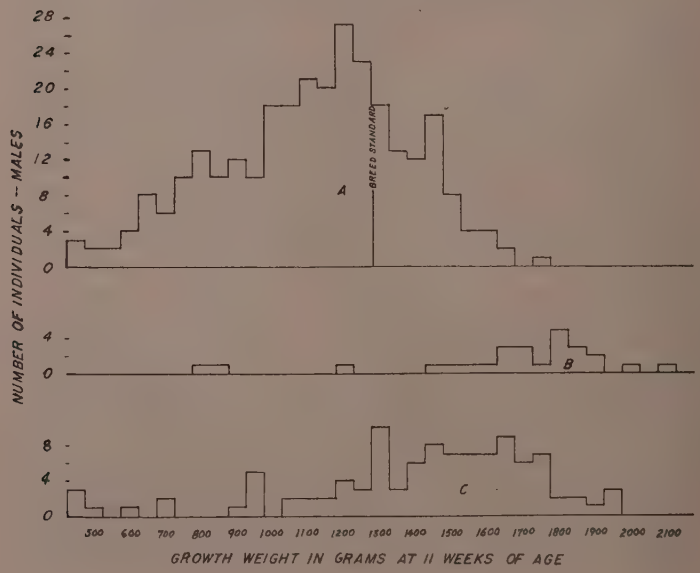
The foods selected by the aggridant type of 51A and 51B (distinguished by the heavy line of the growth curves) when mixed and fed to stock of the same origin produce results in which differences may be distinguished between the two classes of proteins as well as between the two varieties of food crops. The uniformity in the growth of group 52B together with its low mortality rate contrasts strongly with all other groups in which substitutions were made in either one or both of the foods tested. These examples, in which foods of known nutritional differences are used, represent methods applicable to the evaluation of foods of unknown nutritional differences.

vitamin A deficient white corn. In Fig. 51B and 52B, Maine dehydrated fish replaced the meat and by this exchange of one variety of animal protein for another, chicks which would otherwise have died at or before four weeks of age (see Fig. 49B) now live and grow at a more successful rate. From these results it would appear that the dehydrated fish had supplied a fair amount of the factor—vitamin A—missing or low in the white sweet corn. However, the rate at which the dehydrated fish is preferred does not supply quite

all of the missing factor of white sweet corn since the standard combination of both dehydrated fish and yellow corn produces better and more uniform results (Fig. 52B).

These two instances of the use of the individuated bio-assay technic for evaluating the food crops or foods of the State in terms of their ability to supply some need have been presented in detail to emphasize the importance of variety differences in food crops and foods in the prevention of general malnutrition.

(e) *Some Bioecological and Bioeconomic Applications of Food Production for Use.* So far three points have been indicated in the development of a research program based upon production for use; a program directed toward the prevention of malnutrition: (1) That deficiency diseases occur or are found more frequently in those regions of the State lowest in productive rate of superior foods. (2) That experiments indicate the necessity for the development of specialization-diversification patterns of food production within the State, provided first, (3) That the varieties of foods selected for the diversification and specialization be measured, not alone by yield or by market demands, but first by bio-assay of their ability to supply some physiological need to the consumer.



The next and last point to be considered in the adjustments required for the prevention of general malnutrition has to do with bioeconomic factors of food getting.

Experiments based upon the aggridant standard for food needs show that a pioneer diet came nearer to meeting the needs of the consumer than any other food combination.[18] From these pioneer foods the aggridant has selected a combination of these foods which has produced larger growth in the experimental animals (up to eleven weeks) than any combination of foods thus far tested. In Figure 53 and 54, it will be noted that the foods selected by the aggridant Rhode Island Red chick, when mixed and fed to another group from the same breeding stock, caused the latter to grow at a rate equal to and superior to the growth rate of the much larger breed, the Black Jersey Giant, fed the usual ration. This high growth rate made by individuals forced to feed upon the food preferred by superior individuals was secured without the addition of cod-liver oil or any other vitamin concentrate to the diet and yet bone calcification was normal.

The fat-free ash content of tibias of males and females representing the five rates of growth for the group was as follows:

Rate of growth =	1 smallest	2	3	4	5 largest
Males	46.21%	50.20%	49.60%	48.80%	51.85%
Females	51.51%	53.02%	52.88%	52.36%	52.69%

The foregoing experimental results on pioneer diets have an important bearing upon any attempt, through education, research, or government encouragement, to diversify agriculture or to produce superior market foods. The results show that malnutrition and nutritional deficiency diseases, the result of a diet or ration made up of refined foods (another form of over-specialization), may be prevented permanently by a return to the consumption of whole ground grains and to a balance of natural foods.

These particular results, though derived in a different manner and thereby endowed with different implications, come to conclusions similar, in part, to the general thesis of Price[33] and of

[33] Price, Weston, 1939. "Nutrition and Physical Degeneration." New York: Harper Bros.

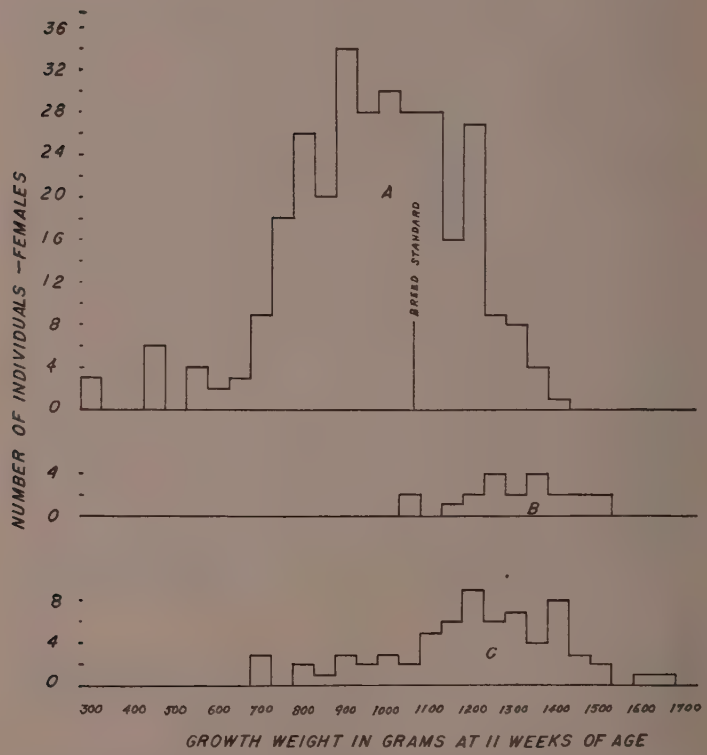


FIG. 53 and 54. Effect of a mixture of aggridant selections of pioneer foods upon growth rate.

A Frequency distribution in growth weight at eleven weeks of age made by N. H. Red males on experimental diets. The breed standard is from N. H. Agr. Exp. Sta. Circ. 52, 1937.

B Frequency distribution in growth weight at eleven weeks of age made by N. H. Red males (experiment of August, 1937) on a mixture of Maine pioneer foods selected by the aggridant type in a previous experiment (experiment of August, 1936). The foods included attrition hammered yellow corn, wheat and oats, dehydrated whole egg, dehydrated white fish, oyster shell and bone meal flour.

C Frequency distribution in growth weight at eleven weeks of age made by Black Jersey Giant males on commercial foods, given for comparison with A and C.

McCarrison[34] on the relation between diet and physical degeneration of races.

To recognize these facts is only the beginning; to turn even facts into practice is a different story. Though some have regarded the rise of present-day malnutrition as the by-product of the "civilizing process" or of "industrialization," these terms have vague meanings when one wishes to apply theory and scientific fact to practice. However, when the cause (and only part of the cause) is considered in terms of a failure by the present industrial civilization to supply a wide distribution of a qualitative pattern of need-satisfactants, one has something tangible in terms of mode of supply for a particular type of demand.

As long ago as 1889 Eijkmann recognized the nutritive value in the bran coating of rice grain. For decades, nutritionists have recognized the value of the bran of wheat, of the germ of grains and the organs of the meat animal as preventors of nutritional deficiency diseases, and yet little has been done to put this information into practice. There are several important reasons for this resistance and several interesting attempts to put grain back together again part by part. The whole trend is so important to the welfare of the consumer as well as to the agriculture of the region that several of these factors will be discussed.

First, the return to whole ground grains for bread-making will require a reduction in the cost of whole wheat flour. During February, 1939, whole wheat flour in twelve different stores of Bangor, Maine, was priced to retail at 7.19¢ per pound or 282 per cent higher than the average low price of 2.55¢ per pound for the refined white flour. Most unrefined foods, because of their poorer keeping and handling qualities and because of their novelty, command higher prices than the devitalized staple refined foods.

In order to make some of these refined foods more valuable nutritionally, there has been a certain amount of research directed toward the addition of the vitamins or minerals taken out by the refining process. An example of the potential inefficacy of this method of correction is shown by a recent reported attempt to make white bread with a vitamin B yeast to replace the amount of vitamin B lost in the refining process.[35] To add this amount of

[34] McCarrison, Col. R. 1932. Problems of nutrition in India. Nutr. Abstr. & Rev. 2:1-8.

[35] Science Supplement 90:2323:12, 7 July 1939.

vitamin to the white flour bread without milk or other mineral bearers would stimulate growth, but would also, at the same time, *hasten* mineral deficiencies through the greater tax of increased growth upon the depleted mineral reserves of the body. To replace a powerful part of the nutritive value of a refined food would be no better and might even be worse than permitting the continuation of the lower rate of existence upon a food depleted in a number of different factors. Furthermore, if parts of the refined flour are to be returned one at a time, why not return all at once—or better still—not refine it in the first place? The difficulties with this conclusion and the effect the conclusion might have upon agricultural production and food-getting will be given consideration a little later.

Second, since methods of refining foods have arisen chiefly since 1870, two human generations have been accustomed to a diet that makes the reversal back to unrefined foods very slow and difficult. Not only have the food habits been built upon refined foods, and preferences developed for refined foods, but the cultural, industrial, and cooking technics bind the method to a continuation. Furthermore, a greater barrier to correction is the effect of refined foods upon the physiological and structural conditions of the human body. An example of one of these barriers is the high rate of tooth defects which mitigate against a return to the consumption of the harder whole-ground grains. In other words, the refinement of foods, in part perhaps the cause of dental defects, causes a continuation in the preference for soft refined foods and hinders the return to the preventive factors to be secured from harder whole grain flour.

Third, the foods consumed by the human being bear a direct relation to the foods consumed by the livestock he keeps. At the present time, man feeds largely upon the refined parts of grain, seeds, meats, and animal products, while he turns over to his livestock the highly nutritious parts removed by the refining process. Thus, while he induces malnutrition in himself by an *under*-balance of refined foods, he induces malnutrition in livestock by an *over*-balance of highly nutritious elements. If, as a permanent corrective to both of these forms of over-specialization, we should attempt to return to the consumption of unrefined foods for the human being, we should simultaneously deprive the animal of his present day rations built upon food by-products. The animal also would

have to be rationed on unrefined grains, and the systems of rationing for livestock would have to be revised for the new kinds of foods not now available for him.

With a fair realization of the numerous difficulties involved in a return of man and his livestock to unrefined foods and rations, nevertheless we have carried on the experiments for several years in the direction led by the aggridant. Furthermore, since man's native ability to detect many of the biological qualities of his own foods has been, even for the wisest, submerged by refined foods and by foods selected for non-biological characteristics, he must now depend upon the experimental test animal more than ever before for that service. And again, with the return of the human dietary to unrefined foods there will be no food by-products for livestock. The two problems—human and animal nutrition—thereby become more nearly one, and the aggridant of the test animal will indicate the way for the selection of superior foods and varieties of crops required for both diets and rations of different productive levels.

Another striking effect upon the agriculture of a section should arise from this change in foods from refined to unrefined. The unrefined foods lack keeping qualities and must be used soon after ground; otherwise they will deteriorate, spoil and become infested with grain-eating insects. Therefore, until new methods of processing and storage are applied grain must be ground near the demand.

In order to meet this future potential demand, tests have been made with a small hammer mill which grinds grain without much rise in temperature and produces a meal more nearly like that secured from the cool stone water wheels of pioneer days. These hammer mills, priced at $100 and up, would grind the whole grains to supply all the demands of the community. With such a mill, grain may be ground at five different degrees of coarseness to fineness to be used for any purpose—for food or feed. The coarser sieves permit grinding for any type of livestock or wild life. The finest sieve of the hammer mill produces a whole meal flour suitable to fine cooking, at a price slightly above the price of whole grains on the market (1.7¢ a pound) and therefore low enough to compete with cheap refined flour. In this method there appears to be one of the quickest routes back to the actual elimination of one form of malnutrition.

When these aforementioned obstacles to the acceptance of nutritional science are removed, the search for food crops will then be based upon evaluations made in terms first of the ability of each variety of each species of food plant to supply some one or more of the nutritive needs and only secondly in terms of the ability of the different varieties to make high yields, produce a high baking or cooking test, or meet some other secondary and sometimes spurious need.

Selections have been in progress for several years on grains and food crops imported from various parts of the world which appear to have potential value in improving, by substitution or by cross-breeding, the nutritive value of the food crops and grains now grown in the State. The modern improved varieties of crops, especially the market crops, are unfortunately poor biological material for this new type of plant breeding, since there appears to be little or no positive correlation between market appeal or marketing characteristics and nutritive value of the food crop. In fact, so frequently does the opposite relation hold that one finds the varieties of highest nutritive value cast out of a breeding program based upon production for exchange.

The effect of research based solely upon production for exchange as its guiding principle may be recognized in the class and variety of food crops grown on every commercial farm and in every home garden. The most striking and obvious trend or characteristic (other than the attempt to secure the largest size of fruit, root, tuber or berry or the heaviest yield) is the emphasis on white-fleshed food crops: white potatoes, white-fleshed apples, white turnips, white rutabagas, white cabbage, and white cereal grains. The "demand" for white foods has gradually eliminated the yellow high carotene and vitamin A carriers, not only from the markets but from the seed supply houses. Varieties of food crops high in carotene and known to exist at one time have now in numerous instances become regionally extinct.

The search for food crops based upon nutritive value must start under these restrictions with quite unfavorable local material. Often, the highly nutritious variety, now unavailable because of the color purge, will be found in foreign countries or in more primitive localities not yet under the influence of the "civilized" demand for white foods.

Thus in foreign countries some promising varieties of cabbage, of buckwheat and of other food crops have been relocated and breeding stock has been secured for a new start. In some instances, with the potato for example, the search for the highly nutritious varieties may have to start from pre-selection days—from the wild parents.

In the attempt to reëstablish plant breeding on a basis of production for use two methods have been pursued to date: first, to recognize that each food crop should have at least one specific use-value, and second, to multiply the use-values of each food or food crop as each value becomes a genetically established trait.

In such a breeding program, native crops are not totally useless. The food crops now available in any region have become acclimated, may be resistant to local diseases and may serve well the local food-culture, and so form valuable genetic stock upon which breeding for nutritional value may be started even though these local varieties may, for the present, be deficient in some important factor. Thus, if one recognizes under the first point the method of selection that the cabbage or the turnip (in regions where citrus fruits are not grown) has special value as a carrier of ascorbic acid, one may overlook, for the present, its low carotene content, since the carotene should have been considered of first importance in some other food crop. Corn, on the other hand, has had a value in the past as a carrier of carotene and should be classified for carotene first. Only after that factor has been satisfied should concern be given for other nutrients or other characteristics. Thus, at the start, the order of importance of ascorbic acid and carotene would be reversed for cabbage from what it is for corn. Later, following continued selection, the two vitamins might come to have equal value in both crops. Only in this manner can the search be successful "in terms of the physiological requirements of man and his livestock as they must exist in the geographical area under analysis."[2]

(f) *The Selection of Genetic Strains of Fruits and Vegetables High in Mineral and Vitamin Content.* Elizabeth F. Murphy and W. Franklin Dove. A broad general program was outlined a few years ago whereby Maine-grown fruits and vegetables were to be analyzed for their content of essential vitamins.[7] Their superiority as foods are to be judged by the results of these analyses as well as by their adaptability to the soil and climate of the region.

A survey of the vitamin C content of Maine-produced foods constitutes a major part of this program. These are being analyzed by the titrimetric method using 2, 6-dicholorophenal indophenol. The determinations have not been confined to varieties which are widely grown in Maine. New and different varieties are being tested with an eye to future demands and future needs. In this way it is hoped that new varieties high in vitamin C and adapted to Maine soil and climate will be brought to light.

Preliminary data have been compiled for several of the leading vitamin C containing foods of the State. The varieties of Maine-grown fruits and vegetables which tested *above the average* in vitamin C content and which thereby may more nearly supply the needs of the aggridant as described before are as follows:[36]

Strawberries: Fairfax, Gibson, Dorsett, Howard 17.
Rutabaga: Large White French, Carter's Imperial, Long Island Neckless Purple-Top.
Onions: Early Red Globe, Yellow Globe Danvers, Silverskin White Portugal, Brigham Yellow Globe, Early Yellow Globe, Southport Red Globe, Mountain Danvers, Southport Yellow Globe.
Tomatoes: King Humbert, Comet, Farthest North, Best of All, Waltham Forcing.
Potatoes: Earlaine, Houma, Bliss Triumph.
Apples: Lodi, Milton, Haralson, Northern Spy, Cortland, Golden Delicious, Baldwin.

The foregoing varieties are suggested for tests on adaptability and are *not* a recommended planting list, since the data on some of the varieties cover only one year and include only a few samples. The analyses were made on raw fresh material grown in Maine under known conditions. During the season of 1939, analyses are being repeated on many of the same varieties to determine the

[36] All records on vitamin C content were secured by one of us (E. F. M.) 1936; 1937; 1938 with the exception of the data on rutabaga which were secured by Miss Jennie A. McIntosh 1937-1938. The above ratings are based upon ascorbic acid content only. Further ratings of varieties for B-carotene and other essential nutrients and characteristics of foods may alter the future rank of any one variety.

extent of seasonal variation.[37] Also new crops and new varieties are being added to the foods under observation.

A further study of varietal differences of the vitamin C values of cabbages is planned this season. Cabbage is a comparatively rich source of vitamin C, especially in the raw state. It may be grown in all sections of Maine and may be stored for consumption during the winter months when there is a paucity of vitamin C bearing foods. Fifteen varieties are being tested, among which five are of the storage type. The effects of storage and of cooking are being investigated. Observations are being made also on adaptability to soil and climate as well as on storage quality.

A phase of the work which is being investigated currently is the effect of locality on the vitamin C content of certain vegetables. Four varieties of tomatoes were grown during the season of 1938 in four widely different sections of the State. Vitamin C determinations were made on these tomatoes at weekly intervals for a period of six weeks. The data obtained were of such a nature as to warrant extending the work during 1939. In order to increase the reliability of the observations, this experiment is being repeated during the present season, using the same varieties of tomatoes and adding two new varieties which were found to be particularly adaptable to soil and climate. In addition, four varieties of cabbages are being grown under similar conditions in order to determine whether the variations hold true for more than one crop.

FORAGE CROPS

ALFALFA STRAIN TRIALS. Russell M. Bailey and Delmar S. Fink. A study of alfalfa strains from different sources is in progress in order to determine those best adapted to Maine. In the preliminary work, reported in Maine Agricultural Experiment Station Bulletin 391, page 277, 1938, Michigan strains A68, A69, A70, Nebraska A31, and New Jersey A65 were found superior and have been placed in a larger second test. Of the commercial strains in the trial, Grimm and Ladack were outstanding and can be recommended for use.

[37] Evidence has been secured in tests on apples which indicates the existence of a direct relationship between sunlight and the ascorbic acid content of the fruit: "Vitamin C and Light" by Miss Elizabeth F. Murphy. Proc. Amer. Soc. Hort. Science 36:498-499. 1938.

See p. 832.

PERMANENT PASTURE STUDIES. Delmar S. Fink and Frank Chadwick, Jr. Table 8 shows the yield of milk in pounds per acre to date from five variously treated permanent pasture paddocks

TABLE 8

The Treatment, Cost, and Yield, in Pounds Milk, Acre Basis, for Five Permanent Pasture Paddocks at Highmoor Farm

Treatment	Cost	Yield, lbs. milk
Paddock 6—Minerals only		
Fall 1935—1 ton limestone	$ 7.50	
Spring 1936—450 lbs. 0-20-20	8.10	
	15.60	1,400
Spring 1937—400 lbs. 0-20-20	7.60	1,850
Spring 1938—400 lbs. 0-20-20	7.60	3,025
Spring 1939—400 lbs. 0-20-20	7.60	2,500
Paddock 7—Complete		
Fall 1935—1 ton limestone	7.50	
Spring 1936—1,000 lbs. 10-9-9	18.10	
	25.60	2,600
Spring 1937—1,000 lbs. 6-8-8	13.60	2,625
Spring 1938—1,000 lbs. 6-8-8	13.60	3,825
Spring 1939—1,000 lbs. 6-8-8	13.60	3,455
Paddock 8—No treatment		
1936		700
1937		675
1938		925
1939		758
Paddock 9—Manure-Phosphate top-dressed		
Fall 1935—1 ton limestone	7.50	
—15 tons manure	30.00	
—300 lbs. 40% superphosphate	6.00	
	43.50	1,500*
Fall 1936—10 tons manure	20.00	
—100 lbs. 40% superphosphate	1.90	
	21.90	1,800
Fall 1937—10 tons manure	20.00	
—100 lbs. 40% superphosphate	1.90	
	21.90	3,325
Fall 1938—10 tons manure		
—100 lbs. 40% superphosphate		3,378
Paddock 10—Manure-Phosphate plowed and seeded		
Fall 1935—This paddock received exactly	43.50	3,000*
Fall 1936—the same treatment as paddock 9 except that it was plowed and	21.90	3,375
Fall 1937—seeded to timothy, Kentucky	21.90	4,225
Fall 1938—bluegrass, and Kent wild clover in the fall of 1935	21.90	3,875

* Milk yields for paddocks 9 and 10 refer to year following treatment.

Note: Milk yields on a standard cow basis, or a 1,000 pound cow giving 25 pounds of 4 per cent milk and obtaining all feed from paddock stated.

at Highmoor Farm. It may be observed that improved permanent pasture is a crop capable of giving returns, over and above treatment cost, comparable to many other crops grown on the dairy farm. Detail cost relations cannot be determined until more time has elapsed. The data show that adequately treated permanent pastures in Maine will produce about 3,500 pounds of 4 per cent milk per acre compared to about 700 pounds for the neglected permanent pasture. This rather large increase in milk yield per acre is not all important. The feed on the treated paddocks has proved to be excellent milch cow feed. It consists of 40 to 50 per cent native white clover regardless of treatment given the various paddocks. This past season milk production was maintained, comparable to that under manger feeding, and live weight increases by mature milch cows was normal, while the herd was grazing the treated paddocks and grain fed according to Morrison's chart for cows on excellent pasture. As a result the herd obtained eighty per cent of its daily requirement of total digestible nutrients from pasture during the period it was grazing on these treated paddocks.

Considerable work is being done with Ladino clover and will be reported upon in detail later. To date it appears that Ladino clover requires about the same lime and fertilizer treatment as is required for good red clover. Excellent stands have been obtained when planted in the spring without a nurse crop, or with oats or canning peas as a nurse crop. Seeding trials have shown that not more than two pounds of Ladino clover seed per acre is required for an excellent stand.

FORESTRY

TREE DISEASES. Merle T. Hilborn. During 1938 a survey was made and some preliminary work done on diseases of forest trees. In a state where forests cover 78 per cent of the total land area and numerous industries depend upon raw materials from the forest, the diseases affecting forest trees are important. Woods also comprise half the farm acreage in Maine and return the second largest income from farm crops.

Elm Diseases. The American Elm is not an important forest tree, but its aesthetic value to Maine makes it one of the most

important trees in the State. With the ever present danger of the "Dutch Elm Disease" becoming established here, elms are being carefully watched for diseases. In 1938 the elm trees in southwestern Maine were found to be rapidly dying from a disease. Over 400 dead trees were found in a small area near Cornish. All attempts to identify the disease failed, but indications are that it may be a virulent disease.

Birch Diseases. The birch stands of Maine are very important and valuable to the hardwood industries. Probably the most serious disease of birch trees in Maine is the "red-heart" of birch. This disease is more common in birch stands that are being grown on poor sites, particularly on thin soil or in swamps. The birch stands of southwestern Maine where this disease is most common are all composed of second-growth trees with sprout or seedling-sprout trees predominating. Here red-heart usually occurs in the first 4- to 8-foot bolt, but sometimes occurs as high as 32 feet up the tree. Red-hearted wood is discriminated against at the mill and thus the existence of this disease in a large part of a birch stand may mean that cutting operations will be conducted at a financial loss to the operator.

Saprogenic Nature of Fomes fomentarius. One of the most common decays of birch trees in Maine is that caused by the tinder fungus, *Fomes fomentarius.* This fungus usually has been considered to cause a decay of the sapwood and the heartwood of dead timber. Work done on this disease during the past three years indicates that the organism gains entrance into the tree through branch stubs or wounds and attacks the heartwood first. As the decay progresses in the tree the sapwood is attacked until finally all the tree is decayed. The first symptoms of the decay in the heartwood are very similar to those found in birch trees affected with red-heart. This phase of the work will be expanded next year and attempts made to determine the possible causes of red-heart in birch trees.

HOME ECONOMICS

A STUDY OF HOW MAINE FAMILIES FINANCE HIGHER EDUCATION FOR THEIR CHILDREN. Pearl S. Greene. As planned, records were made in personal interviews with 200 unbroken families in the State with children in the upper three classes of the Univer-

sity. The distribution was geographically and occupationally representative. Analysis of these records is being made this summer.

Household Equipment. Merna M. Monroe and Pearl S. Greene. *The Effect of the Method of Heat Application, and Accompanying Oven Conditions, Upon the Flavor and Texture of Baked Foods.* The oven conditions to be studied are the method of heat transfer, the effect of superheated water vapor in the oven air, and the methods of loading the oven.

The work so far has been confined to ascertaining methods of introducing the variable to be studied without greatly altering other conditions, so that the pan of food will absorb heat at the same rate under all circumstances. At present, a domestic, electric oven is being used for these tests. Heat transfer by radiation is obtained under normal operating conditions, and transfer by convection is being attempted through the use of a fan in the same oven.

The method of adding water vapor to the oven air without greatly altering other oven conditions has been given considerable attention. In order to simulate the moist-air conditions existing in household ovens during the cooking of foods in uncoverd containers, uncovered pans of water, instead of food, were heated in the oven to provide vapor at a constant rate. This procedure was abandoned because the heat remained on (thermostatically controlled temperature) for much longer periods and the lower part of the oven was much hotter than when no such pans were used. The explanation is believed to be that the water vapor from the surface of the water cooled the upper part of the oven at the level of the thermostat wand, with the result that the thermostat kept the heat on for longer periods. The bottom of baked foods is browned excessively when the lower part of the oven, particularly the baffle, is much hotter than under other circumstances. The procedure originally tried, and temporarily abandoned, of adding steam at 212° F. and heated by a separate source, seems to be a more satisfactory method of adding water vapor than the use of uncovered pans of water.

Water heated more rapidly in a 350°-oven with steam added before and during the heating than it did in a 425°-oven without added steam, but muffins baked under the same circumstances did not show the same tendency in regard to extent of browning. Muffins invariably split badly when baked with steam added rapidly to the oven regardless of whether the baking temperature was 350°

or 425°. The cause of this splitting will be investigated further, and further work done to note effect of oven conditions upon rate of heating and upon baking.

A Study of the Performance of Wood Ranges Heated by Distillate Burners and an Evaluation of Factors Which Affect this Performance. The object of this project is to determine what performance could be expected from a wood range when heated by oil burners which were properly installed and to learn the effect, and magnitude of effect, on performance of certain features of improper installation which are commonly found.

The range and burners were purchased from and installed by a local dealer. This particular range was built of cast iron and had a curved flue strip above the top wall and another one below the bottom wall of the oven. The placing of the burners was such that the top of the sleeves was 5½ inches below the underside of the stove frame, and the oil bottle was placed to maintain a depth of 3/16 of an inch of kerosene in each burner bowl when the valves were open. The rate of flow of kerosene to these stationary, wickless burners is regulated by valves in the feed pipes; the open valve decreases resistance to the flow of kerosene and the partially closed valve increases the resistance.

Tests have been made with the burners as they were installed by the dealer. In comparison with other stoves and sources of heat, the oil burners in the wood range are a relatively slow source of heat. An hour or longer was required to heat the oven from room temperature to 450°. The maximum temperature, 520° F., was obtained with the flames from both burners at the highest operating position and with oven damper closed, check and ash-pit dampers half closed. The lowest oven temperature, 237° F., was obtained with only one flame operated at the lowest recommended position.

The performance of the top of the stove was tested by measuring the time required to heat water. When the heating was begun with the lighting of the burners, 30 minutes was required to heat five pounds of water from 68° to 194° F. in covered, cast-aluminum saucepans, and 20 minutes to heat a kilogram of water. With the stove at a steady temperature and both burner valves at the highest operating position, five pounds of water was heated in 15 minutes and the one kilogram of water in 6 minutes.

To save time in heating water to boiling, many housewives customarily remove the stove lid and place the pan directly over the fire. With the stove already hot, more time was required to heat the water when the pan was directly over the fire than when it was placed on the hot stove lid. When the heating was begun with the lighting of the burners, no time was saved by placing the pan over the fire to heat the large quantity of water. These pans were flat on the bottom and the stove lids were made of comparatively thin metal, two conditions which would facilitate the heat absorption when the stove lid was used. Probably, the burner was cooled by infiltration of cold air under the pan when it was used directly over the burner. The rate at which the kerosene evaporates and is ready for burning depends upon the temperature of the burner; if the burner is cooled by cold air, then the kerosene is burned less rapidly and less heat results.

During maintained boiling with the stove maintained at a steady temperature with both flames on highest operating position, a pan of water received heat at the rate of approximately 2,400 B.t.u. per hour. This is slower than the usual absorption of 3,600 B.t.u. per hour when a gas burner is used, or the 3,300 B.t.u. per hour from a 1,300-watt, electric heating unit. The amount of heat absorbed by the pan of water, or the rate at which water evaporated during full-heat maintained boiling, is of significance in "boiling down" fruit juices for the making of jellies.

The extent to which the stove dampers, other than the oven damper, may be closed and the number of dampers which may be partially closed at the same time depends upon the valve setting for the burners and upon whether the day is windy or calm. With the burners operated at maximum position, not many dampers can be closed on a calm day because the flames will soot badly. More dampers may be closed on windy days or when the burners are operated on low to moderately high flames. Oven temperatures were increased from 20° to 50° by partial closure of the check damper, the ash-pit damper, or the pipe damper when the oven damper was already closed. The temperatures of the rear stove lid became higher than the front lid when the ash-pit or the check damper was partially closed. Not only higher oven temperatures but also higher top-of-the-stove temperatures were obtained by keeping the oven door closed.

INSPECTION SERVICE

WORK OF INSPECTION SERVICE. Elmer R. Tobey, C. Harry White, Bernie E. Plummer, Jr., Glenn H. Perkins, Millard G. Moore, Edward O. Merrill, C. Byron Sibley, and George P. Steinbauer. The Commissioner of Agriculture is the executive of the laws regulating the sale of fertilizers, agricultural seeds, insecticides, fungicides, foods, drugs, and feeding stuffs in Maine. It is the duty of the Director of the Maine Agricultural Experiment Station to analyze or cause to be analyzed the samples collected by the Commissioner and to publish the results of the analyses together with the names of the persons from whom the samples were obtained and such additional information as may seem advisable. This information is reported in the Official Inspections Bulletins published during the year. The State Tax Assessor is the executive of the laws regulating the sale of gasoline and motor lubricants. It is the duty of the Director of the Station to analyze or cause to be analyzed the samples collected by the State Tax Assessor but no provision has been made for the publication of the results of the analyses.

In addition to the inspection service the department is requested frequently to make analyses of various types of materials for individuals. These unofficial samples include milk, cream, vinegar, miscellaneous substances, and materials suspected to contain poison. The results of the analyses on these samples are not published but are reported to the individuals who submit the samples.

A brief summary of the work of inspection is as follows:

Testing of Dairy Glassware. It is required by law that all Babcock glassware used in Maine by creameries, ice cream factories or others buying or selling milk or cream on a basis of the butterfat content must be tested for accuracy at the Maine Agricultural Experiment Station. Nine hundred forty-four pieces have been examined and all but two pieces were passed.

Fertilizer Inspection. Five hundred one samples of fertilizer materials were collected and analyzed. Three hundred fifty-one of these samples are mixed fertilizers containing nitrogen, phosphoric acid, potash, and in some of the samples, magnesium. The samples of mixed fertilizers represent two hundred forty-eight different

brands. The results of the analyses are reported in Official Inspections 169.

Agricultural Seeds, Insecticides and Fungicides Inspection. One hundred eighty-six official samples of seeds were collected and analyzed. The results of the analyses are reported in Official Inspections 170. No official samples of insecticides and fungicides were received.

Food and Drug Inspection. The number and variety of samples collected and submitted depend upon the nature of the inspection work carried on by the Division of Inspection, Augusta, Maine, in the enforcement of the food and drug laws. A large amount of this inspection work does not require the collection of samples. A total number of four hundred eighty samples of blueberries, carbonated beverages, hogshead cheese, honey, maple syrup, oil used in packing sardines, oleomargarine, shucked shellfish, aromatic spirit of ammonia, brown mixture, diluted hydrochloric acid, diluted phosphoric acid, lime water, solution of citrate of magnesia, spirit of camphor, spirit of peppermint, sweet spirit of nitre, syrup of tolu, tincture of gentian compound and tincture of iodine have been examined and the results of the analyses are reported in Official Inspections 171.

Bacteriological Work. A small bacteriological laboratory has been in operation for about fourteen months. A total of two thousand two hundred thirty-five official samples have been examined. Of this number, one thousand four hundred two samples were milk and cream; the remaining number includes seven hundred forty samples of sea water and ninety-three samples of shellfish. In addition, about sixty miscellaneous samples have been examined for municipal departments of health and private individuals. The results of the analyses are reported in the food and drug Official Inspections 171.

Feeding Stuffs Inspection. Seven hundred ninety-seven samples of feeding stuffs were received and the percentages of protein, fat, and fiber in these samples were determined. The results of the analyses will be published in Official Inspections 172.

Gasoline Inspection. Two hundred forty-eight samples of gasoline were received. The results of the analyses indicate that five of these samples were found to require a higher temperature for complete distillation than the maximum temperature (437° F.) specified in the Maine law regulating the sale of motor gasoline.

Motor Lubricants Inspection. Four of the fifty-two samples of motor oils which were examined failed to meet the specifications for the respective brands asked for by the inspector. In practically every instance it appeared to be a case of substitution by the salesman.

LAND UTILIZATION

LAND USE STUDIES IN MAINE. Charles H. Merchant and Andrew E. Watson. The Department of Agricultural Economics is coöperating with the Biology Department in these studies. The Biology Department, in coöperation with the Soil Survey Division of the United States Bureau of Chemistry and Soils, has been conducting a detailed soil survey in York County.

During 1938 the Department of Agricultural Economics conducted a land use study in eleven towns located in southern and south central Aroostook County. A soils map was available for the area and it was possible to obtain aerial photographs of the towns studied. The study in Aroostook County is to be continued another year.

The study shows that in the eleven towns 54.9 per cent of the land area was in permanent forest, 35 per cent in hay and cultivated land, 2.8 per cent in open pasture, and 7.3 per cent was used for miscellaneous purposes. It was found that 39.3 per cent of the farms were located on hard surfaced highways, 23.9 per cent on gravel surfaced highways, and 36.8 per cent on unimproved dirt roads. Of the total road mileage in the eleven towns, 25.8 per cent was hard surfaced, 20.3 per cent was gravel surfaced, and 53.9 unimproved dirt road.

A combination of both electric and telephone facilities was found on 21.6 per cent of the farms. Electricity was used on 35.7 per cent of the farms and telephones on 51.8 per cent of the farms.

The tax revenue collected in the poorer sections of most of the towns was not sufficient to finance the public services demanded by the inhabitants of these areas.

SOIL SURVEY. Joseph A. Chucka, Delmar B. Lovejoy, and John R. Arno in coöperation with Kenneth V. Goodman, of the Soil Survey Division, Bureau of Plant Industry, United States Department of Agriculture. The field work for a detailed soil

survey has been completed for York County. The soils map and a report on the soils of York County will be ready for publication by the end of 1939. Field work in mapping soils has been started in Waldo County. The field work in Waldo County should progress much more rapidly than it did in York County because aerial photographs are available for about four-fifths of Waldo County. With the use of these aerial photographs as a base map it may be possible to complete the field work in Waldo County by November 1, 1940.

MAINE SOIL TESTING SERVICE

SOIL TESTS. Delmar S. Fink and Albert J. Bouchard. The Experiment Station has analyzed over 5,000 soil samples for acidity and available plant food content to date. These analyses together with the suggestions given to the farmer for improving his soil are intended to serve primarily as a bench mark for the farmer to operate from in performing soil improvement practices.

Table 9 is presented to show a soil fertility picture, as gained from soil test, for a number of pea fields in the Dover-Corinna area as gained from soil tests. The data indicate that available nitrogen, phosphorus and potash are at a fairly good level for all fields; at least these three plant food elements, under present fertilizer practices, are being adequately maintained. A low to very low

TABLE 9

Average Acidity and Plant Food Content of Fields in Peas (1939) with Average Yield of Peas Indicated (Dover-Corinna Area)*

Average yield in pounds	Acres in field group	pH	NO_3	P	K	Ca	Mg	Mn	Fe	Al
Poor 725	178	5.22	30	78	189	533	25	13	6	135
Fair 1,356	117.2	5.23	39	85	180	693	30	12	6	147
Good 2,228	118.8	5.30	43	66	150	918	44	27	6	126
Four highest yielding fields 3,335	20.0	5.64	26	90	186	1,591	75	62	8	101

* Plant food content figures are weighted averages in pounds per acre.

level of available calcium and magnesium appears to be mainly responsible for poor yields. Such soil test information must, obviously, be fortified with field experience before being generally accepted. The data, however, definitely indicate a major soil fertility problem in the area.

Practically all of the fields included in Table 9 will be planted to potatoes sometime in the near future. Any program for improving the level of available calcium and magnesium in these soils must take into consideration the rather narrow lime requirement limits of the potato crop. For this reason it is emphasized that the farmer must exercise his personal judgment when putting into effect soil fertility improvement practices.

POTATOES

COSTS AND RETURNS IN PRODUCING POTATOES IN CENTRAL MAINE, 1929-1930. William E. Schrumpf. This study was published under the date July, 1938, as Maine Agricultural Experiment Station Bulletin 392. The bulletin presents (1) the costs and returns in producing potatoes in Central Maine, (2) the effect on costs and returns of such factors as the size of the potato enterprise, yield rates, and labor efficiency, and (3) a method of computing the approximate cost of growing and harvesting potatoes for years other than those considered in the study.

FARM ORGANIZATION AND COSTS AND RETURNS IN PRODUCING POTATOES IN THE ST. JOHN RIVER AREA OF AROOSTOOK COUNTY, MAINE, 1937. William E. Schrumpf. The St. John River Area is one in which economic research in potato production was much needed and in which very little had been done prior to the summer of 1938. Complete labor-income records with especial detail on potato production were obtained for the crop year 1937 from 241 representative farms in 17 towns in the area.

The capital, receipts, and expenses have been computed in detail. The financial summary has been drawn showing the various measures of net income, and the costs of growing, harvesting, storing, and selling potatoes have been computed.

The average capital including real estate, livestock, and equipment amounted to $10,437 per farm. The gross farm receipts averaged $1,616 and the farm expenses $2,395. The farm income,

the difference between receipts and expenses, was $-779 per farm. The cost of growing, harvesting, storing and selling potatoes was $112.48 per acre or 99.3 cents per barrel. Growing accounted for 69.0 per cent of the total cost, harvesting 11.6 per cent, storing 15.4 per cent and selling 4.0 per cent.

Fertilizer Experiments with Potatoes on Permanent Plots. Joseph A. Chucka and Arthur Hawkins. In general the 1938 potato yields on the permanent plots were somewhat lower than average. This was due primarily to late blight injury. An observation worthy of recording is that the seven plots which receive the fertilizer composed of chemically pure salts appeared to resist late blight infection to such an extent that the potato plants on these plots remained green and grew fully ten days longer than those on all other plots. As a result of this longer growing period these seven plots produced an average of 26 more barrels per acre of potatoes than the check plots which received an equivalent amount of plant food from ordinary fertilizer materials. An attempt will be made through further experiments to determine the cause of this apparent resistance to late blight.

Beginning with 1938 four of the permanent plots are being devoted to a comparison of acid versus neutral fertilizers for potatoes. One of the plots receives an acid fertilizer containing added magnesium and the other receives an acid fertilizer without added magnesium. Of the two plots receiving neutral fertilizers one receives a fertilizer neutralized with dolomitic limestone and the other a fertilizer neutralized with calcium limestone. In 1938 the two plots receiving acid fertilizers produced an average of 6.5 more barrels of potatoes per acre than the plots receiving the neutral fertilizers. These treatments will be continued on the same plots over a period of years in an attempt to determine the residual effect of these treatments.

The plots receiving heavy broadcast applications of phosphoric acid and potash in addition to 2,000 pounds of a 4-8-8 in the row produced somewhat lower yields than the check plots which did not receive the broadcast applications. The potatoes produced on the broadcast plots were found to have very poor cooking and baking quality as compared with those produced on the check plots. Since these observations of reduction in yield and quality, but to a lesser degree, were made previously in connection with heavy row applications of fertilizer it would be of real interest to determine their

cause. It is believed at present that the high amount of chloride applied with the heavy potash applications (as muriate of potash) may be at least a contributing cause of the reduced yields and quality. This possibility will be studied in more detail next year.

The plot receiving peat as a source of organic matter produced a somewhat lower yield than the check plot. No explanation can be offered at present for this apparent reduction in yield caused by the application of peat. The treatment will be continued to see whether or not similar results will be secured over a period of years.

The 1938 yield data from the permanent plots comparing rotations, fertilizer ratios, rates of application, and sources of plant food were in general similar to data secured in the past. However, since the potato plants were killed prematurely with late blight the differences between treatments were smaller.

FERTILIZER EXPERIMENTS WITH POTATOES ON PRIVATELY OWNED FARMS THROUGHOUT AROOSTOOK COUNTY. Joseph A. Chucka and Arthur Hawkins in coöperation with Bailey E. Brown, of the Bureau of Plant Industry, United States Department of Agriculture. *Potash Test.* A comparison of potato fertilizers varying in percentage of potash was conducted on two farms. The percentage of potash was varied from 3 to 16 per cent while the nitrogen and phosphoric acid were kept constant at 4 and 8 per cent respectively. On one farm 4-8-7 produced the highest yield and on the other the highest yield was produced by the 4-8-10. The range in yields from lowest to highest was small and the differences obtained do not appear to be significant.

Seed Spacing-Rate Test. In this test four rates of fertilizer application were used with each of three different seed spacings on two farms. The fertilizer rates used were 750, 1,000, 1,250, and 1,500 pounds per acre of an 8-16-14 fertilizer. The seed spacings used were 6, 9, and 12 inches. The data obtained were similar to those obtained in 1937 except that a smaller response to rate of fertilizer application was obtained. Highest total yields were obtained with the six inch spacing. Close spacing tended to reduce the size of tubers and this tendency was most marked with the low rates of fertilizer application.

Source of Phosphorus Test. This test consisted of a comparison of ten different materials as a source of phosphoric acid in potato fertilizers and was conducted on two farms. The materials compared were ordinary superphosphate, concentrated superphos-

phate (treble super), calcined phosphate, calcium meta phosphate, dicalcium phosphate, fused rock phosphate, mono calcium chloro phosphate, potassium meta phosphate, colloidal phosphate, and rock phosphate. Since the response of potatoes to phosphorus is comparatively small under Aroostook conditions, several years' data will have to be considered before a reliable rating can be given to the above materials as a source of phosphoric acid in potato fertilizers.

Boron Test. In this test fertilizers with and without small amounts of borax were compared on three farms. The rates of application of borax were 0, 2.5, 5.0, and 10.0 pounds per acre. The fertilizer with which the borax was mixed was an 8-16-20. No significant differences in yield of potatoes were obtained among the treatments used during 1938.

Pellet Fertilizer Test. This test consisted of a comparison of regular 4-8-7 fertilizer with portions of the same fertilizer either ground into powder or made into pellets of various sizes. The powdered fertilizer was made by grinding until it passed a 40 mesh screen. The pellets were made into three different sizes, 10 to 20 mesh, 6 to 10 mesh, and 4 to 6 mesh. The largest pellets (4 to 6 mesh) produced a somewhat smaller yield of potatoes than the regular 4-8-7 fertilizer. The smaller pellets and the powdered fertilizer produced approximately the same yield as the regular 4-8-7 on the one farm upon which this test was conducted during 1938.

INSECTS IN RELATION TO THE TRANSMISSION OF POTATO VIRUS DISEASES. Geddes W. Simpson. The data obtained in connection with this project have been prepared for publication. The results obtained indicate the possibility of maintaining foundation seed stocks in Aroostook County under certain restricted conditions. These, in brief, include (1) isolation from diseased seed stock sufficient to prevent field to field spread of disease. The distances involved vary from season to season and it appears necessary to determine them for individual locations. (2) Early planting by tuber units of the best seed stocks obtainable in order to permit early roguing of diseased units. (3) Early harvesting of enough seed for the next year's seed plot.

THE PEA APHID NOT A FACTOR IN THE SPREAD OF POTATO VIRUS DISEASES. John Hawkins. There has been some feeling in some sections of Maine that the increase in potato diseases has

been due at least in part to the increase in the acreage of peas grown for canning and freezing.

Observations made over a long period of years indicate that there is no scientific basis for the belief that peas harbor aphids which transmit potato diseases. The common aphid on peas (*Illinoia pisi* Kalt.) does not feed upon potatoes. The rose aphid (*Macrosiphum rosae* Linn.) and the buckthorn aphid (*Aphis abbreviata* Patch) which spread potato diseases have never been recorded as living on peas. The writer has found a single published reference[38] to the potato aphid (*Illinoia solanifolii* Ash.) feeding on peas. In this case the aphids were not outdoors, but were reared in an insectary. Except for the one record of the potato aphid feeding on peas in the insectary, potato aphids have never been observed feeding on peas. A single record of the peach aphid (*Myzus persicae* Sulz.) feeding on peas comes from Florida. In extensive collections made during the past five years in practically all the areas of the State where canning peas are grown, none of the aphids which are known to transmit diseases of potatoes have been taken on peas.

All the evidence available indicates that it is extremely unlikely that the increase in pea acreage has been a factor in disseminating the diseases of potatoes grown in Maine.

GREEN MOUNTAIN SEED PLOTS. Donald Folsom. Tuber-line seed maintained on Highmoor Farm, under an aster-cloth cage in 1935 and in the open in 1936, was grown in 1937 on a number of farms in seed plots. The crops from these seed plots were planted separately in 1938 and examined for disease content to determine to what extent disease had either spread or decreased in the plots in 1937. Also one plot was included which was second-year removed, and another third-year removed, from Highmoor Farm in 1937 instead of first-year removed.

Five lots showed no leafroll in 1937 but these and all the others showed leafroll in 1938. Yellowtop was found in 12 stocks in 1937 but in only one in 1938. Mosaic behaved as follows:

None either 1937 or 1938—9 stocks, including only one in Aroostook County.

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[38] Patch, Edith M. Rose bushes in relation to potato culture. Bul. 303, Me. Agr. Exp. Sta., p. 328, 1928.

Some in 1937 but none in 1938—3 stocks, in Patten and Aroostook County.
None in 1937 but some in 1938—6 stocks, including 5 in Aroostook County.
Some in both years—9 stocks.

Thus, mosaic spread worse in Aroostook County than outside. In fact, the average mosaic percentage in 1938 in stocks grown in Aroostook County in 1937 was 5.43 per cent and for outside was only 0.0009 per cent. This difference was highly significant (odds of about 1,350 to 1). Of 11 seed plots outside Aroostook County, only one produced stock with any mosaic in it in 1938, while of 16 in Aroostook, all but two (in the same field) produced stock with mosaic present in 1938. The average increase in mosaic percentage from 1937 to 1938 was 136-fold for Aroostook stocks, while there was a decrease of about two-thirds in the mosaic percentage from 1937 to 1938 outside Aroostook. In general, as the location of the plot in 1937 was further from the southwestern corner of the State, the more mosaic percentage there was in the replanted stock in 1938 ($r = +0.428$, significant[39]).

Usually leafroll has increased, from one year to the next, much less in Aroostook than outside. The average increase from 1937 to 1938 was 60-fold in Aroostook and 83-fold outside. However, the 1938 leafroll percentage was 10.92 for Aroostook stocks and only 6.34 for outside. The reasons for this unusual result were discussed in last year's report, pp. 298-304. In general, as the location of the plot in 1937 was further from the southwestern corner of the State, the more leafroll percentage there was in the replanted stock in 1938 ($r = +0.270$, not significant).

Among the 27 seed stocks in the study, mosaic percentage in 1937 had a low positive correlation ($r = +0.263$, not significant) with the mosaic percentage in 1938, and there was a lower corresponding correlation for leafroll ($r = +0.138$). The mosaic percentage of 1937 was correlated somewhat with the leafroll percentage of the same year ($r = +0.254$, not significant). Mosaic percentage in 1938 had a highly significant positive correlation ($r = +0.761$) with leafroll percentage in 1938, due to mosaic and leaf-

[39] Significance judged by Table 16 in "Correlation and Machine Calculation" by H. A. Wallace and J. W. Snedecor, Iowa State College Official Public. Vol. 30, No. 4, 1931.

roll both increasing much from 1937 to 1938 in the northeastern seed stocks.

Size of plot in 1937 had no significant effect on mosaic or leafroll percentage in 1938 ($r = -0.129$ and -0.121 respectively), though evidently to some extent the larger the 1937 plot, the less the percentage in 1938.

The earliness of the development of the plants in 1937 showed more effect on leafroll than on mosaic:

Earliness in 1937	Mosaic in 1938	Leafroll in 1938
	Per cent	Per cent
Early	1.21	5.74
Medium	4.88	9.93
Late	2.75	10.56

Thus, early planting and development reduced disease increase, although the differences were not significant.

The plots were classified according to four degrees of isolation in 1937. The replanted stocks averaged as follows:

Isolation in 1937	Mosaic in 1938	Leafroll in 1938	Location
	Per cent	Per cent	
Good	1.52	6.99	Both in Aroostook and outside
Fairly good	1.47	13.24	Ditto
Rather poor	3.05	3.36	Ditto
Poor	9.24	13.02	All in Aroostook

Thus there was less mosaic in 1938 following better isolation in 1937, but no consistent trend with leafroll. None of the differences were significant.

Most of the tuber-unit seed plots in 1937 were in Aroostook, where the greater increase in disease percentages occurred, so that there was twice as much mosaic in 1938, and somewhat more leafroll, in stocks that had been tuber-unit planted in 1937 than in those planted normally:

Planting in 1937	Mosaic in 1938	Leafroll in 1938
	Per cent	Per cent
Tuber-unit	4.46	9.25
Bulk	2.23	8.89

Since there was a tendency for seed stocks to show more mosaic in 1938 following certain conditions in 1937, such as smaller size of plot, greater distance from the southwestern corner of the State, later planting, poorer isolation, and tuber-unit planting, stocks were grouped according to combinations of these features. The most significant differences were:

(1) Plots farther northeast and poorly isolated, 7.68 per cent vs. 0.001 per cent for plots farther southwest and well isolated.
(2) Plots farther northeast and smaller, 7.10 per cent vs. 0.0014 per cent for plots farther southwest and larger.
(3) Plots farther northeast, smaller, and tuber-unit, 7.56 per cent vs. 0 per cent for plots farther southwest, larger, and bulk-planted.
(4) Plots poorly isolated and planted medium to late, 6.70 per cent vs. 0.12 per cent for plots well isolated and planted early.
(5) Plots farther northeast and tuber-unit, 5.94 per cent vs. 0 per cent for plots farther southwest and bulk-planted.
(6) Plots farther northeast, smaller, and poorly isolated, 7.85 per cent vs. 0.014 per cent for plots farther southwest, larger, and well isolated.

Combinations were made also for leafroll, which tended to be more prevalent in 1938 following smaller size of seed plot, greater distance from the southwestern corner of the State, later planting, and tuber-unit planting, in 1937. There were no significant differences, however.

Of the 27 seed plots in the study, 16 were in Aroostook County and were compared in the same ways as the 27. The significant results were as follows:

Leafroll percentage in 1938 was significantly correlated with the leafroll percentage in 1937 ($r = +0.588$) and highly significantly correlated with the mosaic percentage in 1938 ($r = +0.877$), indicating that leafroll spread *within* the seed plot in 1937 more as there was more leafroll originally present and that in addition there was a spread of both leafroll and mosaic together *into* some plots more than into others.

Early planting and development reduced disease spread:

	Mosaic	Leafroll
	Per cent	Per cent
Early	1.41	2.24
Medium	7.66	11.36
Late	8.26	27.27

The averages for early and for late planting were significantly different from each other in each disease.

Combinations were made with these results:

(1) Better isolated plots, planted medium to late, leafroll 20.58 per cent
Poorly isolated plots, planted early, leafroll 1.22 per cent
(2) Poorly isolated plots, planted medium to late, mosaic 8.93 per cent
Better isolated plots, planted early, mosaic 0.15 per cent
(3) Smaller, poorly isolated plots, planted medium to late, mosaic 9.79 per cent
Larger, better isolated plots, planted early, mosaic 0.20 per cent.

Stock grown under cage in 1936 and in the open in 1937, on Highmoor Farm, was replanted in 1938 in ten plots covering about 19 acres. Infection contracted naturally on Highmoor Farm from other fields (a mile or more away) in 1937 appeared in 1938 as 0.012 per cent mosaic and 0.29 per cent leafroll.

WINTER TESTING OF SEED POTATOES FOR VIRUS DISEASES. Donald Folsom, Reiner Bonde, and Geddes W. Simpson. In January, 1938, 44 samples of commercial stored lots of potatoes were planted near Hastings, Florida, to determine their leafroll and mosaic content, which was found to average 19.9 and 3.4 per cent respectively. Included were 27 Green Mountain samples which averaged 23.6 and 4.2 per cent respectively for the two diseases. The information was used particularly by the seed growers who supplied the samples and in general by all growers interested in the then current outbreak of net necrosis. A few comparisons were made between the Florida readings of the samples and the Maine readings of home-planted stocks. Results ranged from agreement

to a variation of 300 per cent in one instance where the Florida sample read 2.2 per cent leafroll and the field read 8.8 per cent leafroll. The latter showed the need of having the sample more representative than was possible when taken from the top of one binful of stored potatoes. A comparison by Student's method showed no significant difference between the two sets of readings, and the correlation was highly significant ($r = +0.930$ for leafroll and $+0.973$ for mosaic in 14 comparisons).

In November, 1938, 83 samples were planted near Homestead, Florida, representing commercial seed fields totaling about 1,500 acres in area, and with leafroll and mosaic averaging 4.5 and 0.6 per cent respectively. Included were 27 Green Mountain samples which averaged 4.9 per cent leafroll and 0.5 per cent mosaic, and 27 Irish Cobbler samples which averaged 3.8 per cent leafroll and 0.3 per cent mosaic.

The Green Mountain samples, the Irish Cobbler samples, and all samples together showed a progressive decrease in leafroll percentage with greater distance of the location of the 1938 source field from the southwestern corner of the State. For example, the 54 Green Mountain and Irish Cobbler samples together showed the following:

Zone in miles from southwestern corner of Maine	160-240	270-285	290	300-310	310-410
Samples	8	14	17	11	4
Average leafroll per cent	15.6	5.1	1.4	0.6	1.1
Average mosaic per cent	0.3	0.3	0.3	0.7	1.1

Although planting at Homestead required treatment of the tubers to break the rest period, results were much more satisfactory than at Hastings. Whereas, at Hastings, leafroll had developed 100 per cent only in chronic leafroll Green Mountain check stocks by 50 days after planting, and leafroll readings could not be completed in Green Mountain commercial lots until more than two months after planting, at Homestead leafroll readings could be completed in Green Mountain commercial lots about 50 days after planting. Still more important was the earliness of planting possible at Homestead, which is much warmer than the Hastings area. In the latter there is constant danger of killing frosts which will ruin the test if occurring at certain times.

Each sample was planted in part by tuber unit and in part with the tubers left whole. On the average there were 98 tuber units and 573 hills grown from whole tubers, in each sample lot as grown. With disease percentages generally low, about 27 per cent of the lots had leafroll only in the whole-tuber part while 4 per cent had leafroll only in the tuber-unit part; and about 34 per cent of the lots had mosaic only in the whole-tuber part while 6 per cent had mosaic only in the tuber-unit part. That is, with about six times as many tubers in the whole-tuber part as in the tuber-unit part, there was about six times as much chance for leafroll or mosaic to be included in the whole-tuber part, in samples with little of either disease. This shows that 600 tubers are about six times as reliable as 100 for disclosing a small amount (0.8 per cent or less) of leafroll or mosaic. Another set of comparisons showed that when 700 tubers, as in the whole sample, give a reading of about 3 per cent disease, the reading on 100 tubers of that sample can be expected to be anywhere from about 1.1 per cent to about 4.9 per cent if following only the average variation. Finally, when the 700 tubers give a reading of about 3 per cent disease, the reading on 600 tubers of that sample can be expected to be anywhere from about 2.7 per cent to about 3.3 per cent if following only the average variation. Therefore at the critical percentage for disqualification for certification on account of mosaic or leafroll, namely, about 2 to 4 per cent, 700 or 600 tubers make a much more reliable sample than 100 tubers.

Some samples from experimental fields were included. One series consisted of five picked from the same 800 barrels in the same way and as similar as possible. These showed the following variation:

Sample No.	1	2	3	4	5
Leafroll per cent	3.7	4.8	4.6	4.2	3.7
Mosaic per cent	12.9	10.4	10.5	9.1	7.6
Both diseases per cent	16.6	15.2	15.1	13.3	11.3

This gives a range, in several samples as identical as can be made, from 3.7 to 4.8 per cent leafroll, from 7.6 to 12.9 per cent mosaic, and from 11.3 to 16.6 per cent of both diseases together. As these five 800-tuber samples were combined in different ways to give progressively larger samples, we have the following relationships:

Tubers	Leafroll	Mosaic	Both diseases
	Per cent	Per cent	Per cent
800	3.7 - 4.8	7.6 - 12.9	11.3 - 16.6
1,600	3.7 - 4.7	8.3 - 11.7	12.3 - 15.9
2,400	3.9 - 4.5	9.0 - 11.3	13.2 - 15.6
3,200	4.1 - 4.3	9.4 - 10.7	13.7 - 15.0
4,000	4.2	10.1	14.3

Therefore, although more than 800 tubers would be necessary to give a reading reliable enough for some purposes, 800 (the average number in two Argentine crates, a package suitable for shipment by boat) apparently would give results of practical usefulness.

Field readings were secured in the summer of 1939 on 60 of the 83 seed stocks sampled for Florida, and generally showed closer agreement with the whole-sample reading (on about 700 tubers) than with the tuber-unit reading (on only 100 tubers) secured in Florida. The list of recommended stocks made up from the Florida whole-sample readings not exceeding the certification tolerance of leafroll 2.0 per cent and mosaic 3.0 per cent had included 47 stocks that were seen in the field in Maine. These 47 recommended stocks included only two that were more than 2.0 per cent leafroll in the field and omitted only two that were 2.0 per cent or less in the field. They neither included nor omitted any stocks wrongly with respect to mosaic. Above the tolerance limits of the certification requirements there was less agreement, but this is of no practical importance inasmuch as the purpose of the test is to indicate ahead of the planting season which seed stocks are likely to be suitable for certification with little or no roguing.

The correlation was highly significant between the Florida whole-sample reading and the Maine reading. The accuracy of the Florida readings, the leafroll percentage in Maine, and the mosaic percentage in Maine, were not significantly correlated with the size of the field sampled. Correlations are as follows:

	Leafroll	Mosaic
Whole-sample reading in Florida vs. Maine reading	$r = +0.969$	$r = +0.737$
Acres in sampled field vs. absolute difference in percentage between Florida and Maine readings	$r = -0.082$	$r = -0.048$

Acres in sampled field vs. relative difference in percentage between Florida and Maine readings	$r = -0.193$	$r = +0.147$
Acres in sampled field vs. percentage in Maine reading	$r = -0.109$	$r = +0.136$

The list of recommended stocks, the samples of which gave readings in Florida less than the Maine certification tolerances with respect to leafroll and mosaic, were produced on about 1,500 acres. At a rate of one to ten, this means that these stocks should have planted 15,000 acres in Maine during the summer of 1939.

NET NECROSIS AND STEM-END BROWNING. Donald Folsom and Avery Rich. Net necrosis, as considered here, is a dark phloem necrosis of the potato tuber caused by a leafroll virus, being exclusive of another form of internal discoloration called stem-end browning which is a darkening of conducting strands with cause unknown. The term "net necrosis" as used by the trade usually includes all kinds of internal discoloration.

Complaints from Aroostook County in the early winter of 1937 led to the examination of samples in 52 Green Mountain bins which averaged about 16 per cent net necrosis around Houlton, more to the southward, and about 8 per cent near Mars Hill and northward. Only three lots of Green Mountains had more stem-end browning than 2 per cent. Katahdin and Chippewa tubers had no net necrosis or stem-end browning in this or any other survey.

Students were instructed regarding distinctions between net necrosis and stem-end browning and then examined about 100 tubers in each of 119 Green Mountain bins, during the Christmas vacation. They found about 17 per cent net necrosis in southern, 6 per cent in central, and 1 per cent in northern, Aroostook.

The possibility of a relationship between the depth of discoloration and cause was tested in greenhouse plantings of affected samples. Tubers that were considered to have stem-end browning or probable net necrosis and that produced healthy plants had an average depth of discoloration of about one-half inch, while tubers considered as having stem-end browning or probable net necrosis and producing leafroll plants had an average depth of discoloration of over an inch. The differences were highly significant. Therefore, although occasional tubers showed discoloration an inch deep and

produced healthy plants, as a rule discoloration of only one-half inch depth did not indicate leafroll.

In Florida in January, 1938, about 19,000 tubers were examined individually in 44 samples for internal discoloration at the stem end. A thin shaving was first scraped or gouged out around the stolon scar with a stiff-bladed knife for disclosing the shallow typical stem-end browning if present. If no discoloration was thus found, the tuber was called "clear-fleshed." If discoloration was found, another cut was made, this time with a sharp knife to take off a slice of potato about one-half inch thick. If no discoloration was then apparent in the remaining main portion of the tuber, the tuber was recorded as having stem-end browning. If it was found that there was discoloration beyond this depth, a guess was made whether it was that of severe stem-end browning, probable net necrosis, or typical net necrosis. Usually discoloration in more than one ring at the half-inch depth was called probable or typical net necrosis rather than stem-end browning. An examination of the plants grown from representative tubers from several samples gave the following results:

Type of tuber	Total tubers	Leafroll
		Per cent
Clear-fleshed	1,206	14
Stem-end browning	286	23
Probable net necrosis	143	87
Net necrosis	50	100

About 14 per cent of the tubers classified as having stem-end browning would be expected to produce leafroll plants in any case, because of that much being shown by the clear-fleshed tubers. The additional 9 per cent may be attributed to 9 per cent having a mild net necrosis (due to leafroll) but indistinguishable from the stem-end browning (with cause unknown). Of the tubers considered as probably net necrosis, only 13 per cent did not produce leafroll hills. This 13 per cent may be considered as having stem-end browning in severe degree.

A third survey was attempted in late winter through an appeal to growers, of whom about 100 replied by sending data which showed again that the severity of discoloration was greater with progress further south in Aroostook County.

The greater prevalence of either net necrosis or severe internal discoloration with progress southward, as shown by all three surveys, is in line with experience of recent years with leafroll, which generally spreads worse with progress further south in the State. When leafroll spreads during one summer, one effect is net necrosis in storage and another effect is more leafroll the next summer. The outbreak of net necrosis was correlated with an unusually high percentage of leafroll in Aroostook fields in 1938. About 80 Green Mountain fields averaged about 8 per cent leafroll.

On two farms where experimental work is being done, net necrosis was reported worse in the later planted parts of a seed stock. At one place the State seed certification inspector found no net necrosis in 60 cars from fields planted previous to May 20 and up to 18 per cent in other stocks from fields planted after May 20. The replies to our third survey, mentioned above, showed a trend of more net necrosis with later maturity of the vines. All this is in line with the results of seed-plot work over the last several years showing that often with later planting and development of the vines there is a greater spread of leafroll.

The ratio of leafroll percentage to net necrosis percentage (typical and probable combined) in the same lot was found in the Florida test of 1937-1938 to vary from 1 to 1 up to 9 to 1, averaging about 3 to 1, with a highly significant correlation ($r = +0.557$). The correlation was slightly greater between the typical net necrosis percentage and the leafroll percentage ($r = +0.589$) but the ratio, averaging 13 to 1, varied from 5 to 1 up to 100 to 1. Therefore, while net necrosis in general may indicate how much leafroll is present in a region or season's crop, it is not a reliable indicator of the percentage of leafroll in individual lots.

The student survey referred to above showed that there was about as much net necrosis in one part of the bin as in another, judging by the amounts shown respectively by one group sampled in the upper part only and by other groups sampled otherwise.

Eight bags yielding about 255 tubers, or 80 pounds, apiece were put up for us by one grower. In aggregate weight, net-necrosis tubers varied from 1.4 to 4.2 per cent of a bagful. To reduce the range of variation to less than one per cent (absolute), about 420 pounds would have to be sampled for a reading. That is, readings would run from 2.3 to 3.3 per cent by weight per sample if there were 420 pounds in a sample (obtained by combining consec-

utive bagfuls). Another shipment of ten bags yielded about 210 tubers, or 60 pounds, apiece, and the net-necrosis readings ran from 9.7 to 22.7 per cent per bagful. Sampling as much as 500 pounds at a time (consecutive bagfuls) did not reduce the range of variation below that of 15.5 to 16.9 per cent, absolute. Variation in probable net necrosis and in stem-end browning was more regular, so that it was reduced in the two lots to an absolute difference of 1.0 per cent at smaller sizes of samples as follows:

Lot 1, probable net necrosis, 1.4 to 2.4 per cent at about 200 pounds.

Lot 2, stem-end browning, 6.8 to 7.8 per cent at about 335 pounds.

Lot 2, probable net necrosis, 11.1 to 12.1 per cent at about 400 pounds.

Lot 1, stem-end browning, 19.2 to 20.2 per cent at about 450 pounds.

Therefore if inspectors wished to be sure that their reading for percentage of discoloration going more than one-half inch deep would be within one per cent of another reading from the same part of a shipment, they would have to examine larger samples according as there was more of the *typical* net necrosis and as there was a larger *proportion* of the stock affected with any net necrosis. At the five per cent level they would have to examine about 335 pounds if the proportion of typical net necrosis ran as it did in this study. The amount in pounds will vary inversely with the number of tubers per 100 pounds. The number here was 350.

These two lots of potatoes were studied with respect to the relationship of average tuber weight to several types of internal discoloration, with the following results:

	Lot 1	Lot 2
	Ounces	Ounces
Average weight, all tubers	4.95	4.27
" " , clear-fleshed tubers	5.03	3.97
" " , stem-end browning tubers	4.61	3.56
" " , probable net-necrosis tubers	4.85	5.03
" " , net-necrosis tubers	5.15	6.01

Therefore stem-end browning was more abundant in tubers of less than the average weight, and net necrosis generally in tubers of more than the average weight.

Each of these two lots of potatoes was divided into several parts identical as to the proportion of various tuber sizes and as to source (same amount from each bag). These identical parts were examined respectively on successive dates. There was no corresponding increase or decrease in the percentage of stem-end browning or net necrosis. Therefore when this study was begun, about December 15, all tubers had shown discoloration that were going to show it and had respectively shown the same type that they were going to show later.

Replicate samples, similar to those referred to above, were stored for several months at different average temperatures, namely, 14, 35, 43, 46, 53, 71, 73, 86, 96, and 102 degrees F. At 14° they were, of course, frozen solid, and at 102° they were soon ruined by blackheart. Duplicate samples were stored at 46°. Examination was made for types, extent, and degree of internal discoloration and there was found a tendency for more to develop at 35, 46, and 53°, than at 43 (varying from 32 to 64), 71, 86, or 96 degrees.

Another storage test was made during the winter of 1938-1939. The larger tubers from certain Green Mountain rows at Highmoor Farm were used to make 20 replicate samples, each sample coming from all the rows in equal proportion and having the same range of tuber size. Some of these samples were kept in cold storage at 40° F., some in a cool basement room, and some in a warm room, and in each place samples were examined on successive dates to determine when stem-end browning and net necrosis began to develop. Practically none developed except in the basement room, where the maximum of 3.1 per cent net necrosis was reached November 23 after the mean temperature had dropped from 55 to 46° F. Still other samples were kept respectively at 42, 56, 76, and 83 degrees F., and developed respectively 11, 13, 0, and 0.1 per cent net necrosis.

Simultaneously a similar study was made of field-run stock from an Aroostook Farm field. In the basement room, net necrosis reached a maximum of 1.3 per cent December 27 and stem-end browning reached 5.8 per cent February 11, the last date of sampling. Practically none developed in cold storage at 40° F. or in the warm room. Other portions kept respectively at 42, 56, 76, and 83 degrees F. developed respectively 1.9, 1.3, 0.3, and 0.4 per cent net necrosis and 1.9, 3.2, 0.7, and 0.7 per cent stem-end browning.

The tendency in these two stocks for stem-end browning and net necrosis to develop more at 42 and 56 degrees F. than at higher temperatures is in agreement with the results of the preceding winter. However, to have so little develop in cold storage may be surprising.

OBSERVATIONS ON THE PREVALENCE AND EFFECT OF POTATO DISEASES IN MAINE DURING 1938. Reiner Bonde. The season of 1938 was characterized by the presence of an abnormally large amount of potato diseases in Aroostook County, Maine. The seriousness of the virus disease problem can be appreciated by observing data supplied by the State potato seed certification service. Table 10 gives the acreages of potatoes of the different varieties entered for certification in 1938 and the number of acres and percentages that finally were accepted.

TABLE 10

Potatoes Entered for Seed Certification in Maine in 1938 and Acres and Percentages of Total Finally Accepted

Variety	Acres entered	Acres passed	Percentage passed	Percentage rejected	Major reason for rejection
Green Mountain	11,541	5,200	45.0	55.0	Leafroll
Irish Cobbler	10,727	6,038	56.3	43.7	Leafroll
Spaulding Rose	861	350	40.6	59.4	Leafroll and rugose mosaic
Katahdin	2,638	1,439	54.5	45.5	Bacterial wilt
Chippewa	4,099	593	14.5	85.5	Leafroll
All others	1,446	693	47.9	52.1	Leafroll

The chief reason for the high percentage of rejected seed stocks for certification was the presence of excessive amounts of leafroll. This disease occurred in epidemic proportions as a result of an increase in 1937 in the population of the peach aphid *Myzus persicae*.[40] Leafroll was prevalent in all varieties excepting the Katahdin. Some mild mosaic was present in the Green Mountain variety, and rugose mosaic was abundant in some fields of Spaulding Rose. The Katahdin variety was relatively free of the virus diseases but had contracted wilt and soft rot which resulted in the rejection of some fields for certification.

[40] Information supplied by Dr. Geddes W. Simpson of the Maine Agricultural Experiment Station.

Table 11 gives the amount of leafroll and mosaic found in some commercial potato fields. The disease counts were obtained from fields of different varieties selected at random and give a fair conception of the amount of virus diseases that were present in Aroostook County, Maine, in 1938.

TABLE 11

*Leafroll and Mosaic in 1938 in Commercial Potato Fields**

Variety	No. of fields	Leafroll per cent			Mosaic per cent			Locations
		Min.	Max.	Average	Min.	Max.	Average	
Green Mountain	68	0	82	7.6	0	88	7.0	Leeds Junction to Fort Fairfield
Irish Cobbler	12	1.5	29	7.8	0	1	0.3	Aroostook
Chippewa	16	2	76	30.5	0	Trace	0	Aroostook
Katahdin	11	0	1	0.3	0	Trace	Trace	Aroostook
Rural	2	4	15	9.5	0	Trace	0.5	Fort Fairfield
Spaulding Rose	31	0	80	7.6	0	60	12.6†	Aroostook

* Summary of data secured by Donald Folsom and Reiner Bonde.
† Rugose mosaic was present in the Spaulding Rose variety. This disease generally is not disseminated extensively in Aroostook County, Maine.

It is to be noted that leafroll was present in great amounts. Some seed stocks were from 70 to 82 per cent infected with the disease. Experiments have shown that the dissemination of leafroll in Aroostook County is not important in normal years. Of interest is the fact that the Katahdin variety did not become infected with leafroll under the same conditions in which the other varieties became badly contaminated. The Chippewa variety, which originated from the same cross and seed ball as Katahdin, was very susceptible and only 14.5 per cent of the acreage passed the requirements for certification.

The Spaulding Rose variety has normally been very resistant to the virus diseases in Aroostook County and is easily propagated in disease-free condition. In 1938 many fields of this variety were badly contaminated with leafroll and rugose mosaic, the latter appearing in some stocks to the extent that from 40 to 60 per cent of the plants were infected.

It is expected that the new seed potato program to be conducted under the direction of the Experiment Station will be a factor in improving the condition of our seed stocks. By eliminating all undesirable seed stocks and by rigid roguing practices and the

development of more isolated tuber-unit seed plots, the present condition should soon be overcome.

Losses from Tuber Decay Caused by Phytophthora Infestans. The season of 1938 was probably the most favorable for the development of late blight in the history of Aroostook County. Some field infection on the foliage was observed the first week in July and its spread continued throughout the entire season. Spraying and dusting were carried on more in earnest than ever before, and the control of blight in the fields seemed to be quite successful.

After the crop was dug, reports were received that the late blight rot was present in all parts of the County. Potato inspectors reported the greatest loss from decay that has occurred in years. In the Limestone area, extreme shrinkage was reported from ten growers, the rot averaging from 10 to 40 per cent of the crop. The shrinkage encountered in the other potatoes stored at Limestone was 4 per cent, and the average loss from late blight decay in the section was probably from 6 to 8 per cent of the entire crop. Tuber decay was present to some extent in all of the late potatoes stored at Fort Fairfield and occasional lots showed 30 to 35 per cent shrinkage. Similar losses from late blight rot occurred at Presque Isle, Washburn, Westfield, and Mars Hill. Several lots of potatoes in Mars Hill and Westfield settled 2 feet after being in storage for several weeks, because of the potatoes decaying, and one bin in Bridgewater containing 900 barrels was a complete loss.

A questionnaire in regard to the presence of late blight rot was issued to farmers in Aroostook County. A reply was received from 511 of these farmers and 167 reported the presence of late blight at digging time. The amount of decay that was reported at digging time was from a trace to 3 per cent. Much rot developed in the bin. The total amount of loss resulting from late blight decay is estimated at 5 or 6 per cent of the crop for the entire County. These losses occurred in spite of large expenditures for the application of fungicides.

Bacterial Wilt and Soft Rot. This disease is claimed by Burkholder[41] to be bacterial tuber ring-rot described previously in Germany. The disease described in Germany is caused by *Phytomonas sepedonica* Spieckerm. and Kotth.

[41] Burkholder, Walter H. The occurrence in the United States of the tuber ring rot and wilt of the potato. American Potato Journal 15: 243-245. 1938.

Bacterial wilt and soft rot was first discovered in Maine in 1932. It appeared in epidemic proportions in 1937 and again in 1938. The disease was present mostly in the Spaulding Rose variety in 1937. Records show that 315 acres or 28 per cent of the total acreage of this variety entered for certification were affected. The infected fields in 1937 were limited to a rather small area in Aroostook County. Bacterial wilt and soft rot appeared mostly in the Katahdin variety in 1938 and to some extent in Green Mountains.

Studies conducted in Aroostook County have shown that bacterial wilt spreads very rapidly under field conditions and that seed stocks with even a trace of the disease should not be used for seed purposes.

One of the chief methods by which wilt is spread is the contamination of the freshly-cut seed pieces by the seed cutting knife or by diseased tubers. It apparently is spread by soil water in the field. Roguing and other seed plot practices have failed to eradicate wilt in Maine. It was not possible to detect all the disease by examination of the tubers during the process of cutting the seed prior to planting. The only known method of controlling wilt is by the use of disease-free seed. The effectiveness of this method in eradicating wilt is shown by the fact that the disease was practically eliminated from the Spaulding Rose variety in one season by the use of disease-free seed stocks. It is expected that by rigid enforcement of certification rules and by insisting that only disease-free stock be used for seed potatoes, bacterial wilt will be eradicated from Maine potato fields.

Effect on Yield of Different Amounts of Leafroll. The presence of leafroll in commercial fields often has raised the question regarding the reduction in yield caused by this disease.

Tables 12 and 13 summarize the results of tests conducted in 1938 in which yields were obtained from seed stocks containing different amounts of leafroll. The data show that the disease, if present in large amounts, materially reduces the yield. Small percentages of leafroll, however, do not greatly affect the yield, a fact not generally appreciated by growers.

Comparison of Sebago and Green Mountain Potato Varieties. The season of 1938 was very favorable for the development of late blight, and afforded conditions that were ideal for comparing the Sebago and Green Mountain varieties under severe disease conditions.

TABLE 12

Yield of Irish Cobbler Variety with Different Percentages of Leafroll in 1938*

Per cent leafroll	Yield per acre†		Reduction in yield per acre		
	Barrels	Bushels	Barrels	Bushels	Per cent
0	114.8±2.57	315.9±6.29	—	—	—
10	112.5±2.79	309.4±7.77	2.3	6.5	2.0
20	103.7±2.76	285.2±7.91	11.1	30.7	9.6
30	104.9±1.20	288.7±2.13	9.9	27.2	9.4
100	40.9±2.31	112.6±6.18	73.9	203.3	64.3

* The different percentages of leafroll were obtained by the addition of seed pieces from tubers affected with net necrosis to a healthy seed stock.
† Average of 4 randomized plots each consisting of 115 feet of row. One hundred seed pieces planted by hand, 14 inches apart in the row.

TABLE 13

Yield of Green Mountain Variety with Different Percentages of Leafroll in 1938*

Per cent leafroll	Yield per acre†		Reduction in yield per acre		
	Barrels	Bushels	Barrels	Bushels	Per cent
1-2	146.2±2.96	402.1±8.04	—	—	—
7	136.4±2.30	374.9±6.64	9.8	27.2	6.7
12	125.5±1.20	345.2±3.40	20.7	56.9	14.2
17	121.2±2.65	333.2±7.38	25.0	68.9	17.1
25	121.5±2.24	334.1±7.45	24.7	68.0	16.9
31	112.7±2.28	310.2±6.39	33.5	91.9	22.9
37	120.6±2.84	331.8±7.61	25.6	70.3	17.5
52	103.4±2.16	284.0±5.96	42.8	118.1	29.3
100	45.0±1.67	124.0±4.60	101.2	278.1	69.2

* The different percentages of leafroll were obtained by the addition of seed pieces from tubers affected with net necrosis to a seed stock containing 2 per cent leafroll.
† Average of 10 randomized plots each consisting of 115 feet of row. One hundred seed pieces planted by hand, 14 inches apart in the row.

Two separate plots were studied on Aroostook Farm comparing these varieties. One of the plots was sprayed 7 times during the season and the other was left unsprayed. The two varieties were grown in alternate rows in the plots and were replicated 7 times in rows that were 65 feet in length. The yield data got from this experiment have been summarized in Table 14.

The Green Mountains in the unsprayed plot were destroyed rapidly by late blight and the total yield was only 22 barrels per acre of small sized potatoes. The Sebago variety in the same experiment yielded 85 barrels per acre of marketable tubers. Late blight attacked the Sebago potato late in the season and caused a

TABLE 14

Yield Comparison of Sebago and Green Mountain in Sprayed and Non-Sprayed Plots on Aroostook Farm in 1938

Variety	Yield rate per acre*		Decay in tubers of sprayed plots
	Sprayed	Not sprayed	
	Barrels	Barrels	Per cent
Green Mountain	54±1.84	22±0.95	10-15
Sebago	144±2.07	85±2.05	None

* Yields based on one row plots each 65 feet long and replicated 7 times.

considerable amount of defoliation of the lower leaves. The plants, however, were not killed by the fungus and a fair crop was secured in spite of the fact that the blight epidemic was severe and that the rows of Sebagos were buffered on both sides by rows of the susceptible Green Mountain variety which supplied an abundance of inoculum. In the absence of this supply of infection the Sebago variety would have been less infected and the yield would have been higher than those just mentioned in this test. It is of interest that a two acre block of Sebago potatoes which were not sprayed and grown in close proximity to the above mentioned yield test yielded 110 barrels per acre.

The data in Table 14 show also that the yield of Sebago was very much superior to that of Green Mountains in the sprayed plots as well as for the plots that were not sprayed. The Sebagos that were sprayed yielded 144 barrels per acre in comparison with only 54 barrels per acre for Green Mountains, which were injured by late blight in spite of being sprayed.

The Sebago potato performed well also at Silvers Mills, located in central Maine, the yield per acre being 109 barrels per acre in comparison with 82 barrels for Green Mountains grown in the same field.

EFFECT OF SHALLOW VERSUS DEEP PLANTING ON YIELD AND ON THE PER CENT OF RHIZOCTONIA AND UNMARKETABLE TUBERS IN THE CROP. Reiner Bonde. The question is raised often whether the amount of rhizoctonia on seed potatoes can be reduced by shallow planting. In 1938 a test was conducted to gain information on this subject.

The Irish Cobbler variety was used in these tests and the

experiment was conducted with infected and with disease-free seed stocks. The infected and healthy seed pieces were planted at three different depths, namely (1) normal, (2) shallow with seed pieces two inches higher in the soil than for normal planting and covered with 1 inch of soil, (3) deep with seed pieces two inches lower in the soil than for normal planting. The normal and the deeply planted treatments were kept hilled as is normally done in Aroostook County and flat cultivation was practiced for the shallow planting.

The results of this experiment are summarized in Table 15. The data indicate that shallow planting of the seed pieces produce somewhat more unmarketable tubers than normal or deep planting. Shallow planting also gave reduced yields in comparison with the other treatments. The number of rhizoctonia sclerotia on the tubers was approximately the same for the three depths of planting. In these tests planting the seed pieces at the normal depth produced the highest yields.

It is apparent from the data in Table 15 that planting seed stock that is relatively free from rhizoctonia is advisable. Disease-free seed gave the highest yields in all cases when compared with seed stock that was infected. The amount of disease present on the harvested tubers also was reduced by the use of disease-free seed.

TABLE 15

*Effect of Shallow vs. Deep Planting on Yield and on the Per Cent of Rhizoctonia and Unmarketable Tubers in Crop, on Aroostook Farm in 1938**

Infection on seed pieces	Depth of planting	Total yield per acre		Rhizoctonia tubers	Unmarketable tubers
		Bushels	Barrels		
				Per cent	Per cent
1. Present	Deep	284± 9.94	103	38.2	6.5
2. "	Shallow	291±10.53	106	38.2	9.7
3. "	Normal	359± 4.67	131	25.0	6.0
4. None	Deep	372±10.08	135	7.8	7.8
5. "	Shallow	364± 5.05	132	0.01	9.3
6. "	Normal	407±12.17	148	0.03	4.6

* Irish Cobbler variety used throughout test.
Used 8 replications each consisting of 25 hills.

THE EFFECT ON YIELD OF ADDING DIFFERENT FUNGICIDES TO THE FERTILIZER FOR THE CONTROL OF RHIZOCTONIA. Reiner Bonde and Donald Folsom. Experiments were conducted in 1938 to test

further the benefits of adding certain fungicides to the fertilizers for the control of rhizoctonia infection on the tubers. In 1937 a plot that had grown potatoes for several years in succession at Highmoor Farm was found to be infested with rhizoctonia enough so that of pea vines, over 99 per cent were infected and of Irish Cobbler tubers over 50 per cent were black-scurfy. In 1938 this plot was replanted with potatoes for a test of the effect of adding mercurial materials to the fertilizer at the rate of 4.25 pounds of mercury to the ton of fertilizer. The fertilizer was applied by hand at the rate of a ton to the acre, and was mixed with the soil by hand. The mercurial materials retarded vine growth, postponed vine maturity slightly, reduced the yield rate 23 to 37 per cent, and reduced the percentage of black-scurfy tubers only 31 per cent in the most effective series. A zinc-mercury amalgam reduced the scurf somewhat more than corrosive sublimate, yellow oxide of mercury, and calomel.

Experiments were conducted also on Aroostook Farm at Presque Isle and on the farm of Ray Hews at Easton. The fungicides were added to the fertilizer in proportions so as to contain equal amounts of mercury for each treatment. The data obtained from these Aroostook tests are summarized in Table 16.

The data in Table 16 give certain interesting facts. It is to be observed that the per cent of tubers that were infected was not reduced by the addition of the fungicides to the fertilizer. The severity

TABLE 16

*The Effect on Yield and Percentage of Rhizoctonia on Tubers Resulting from Adding Different Fungicides to the Fertilizer in 1938 in Aroostook Tests**

Fungicide added to fertilizer	Yield rate per acre		Rhizoctonia on tubers†	Culls†
	Hews Farm	Aroostook Farm	Per cent	Per cent
Control. None added	119	117	22	6
Corrosive sublimate	104	107	33	12
Yellow oxide of mercury	103	104	31	9
Zinc-mercury amalgam	116	107	32	7
Calomel	117	117	28	8

* The fungicides were added so as to contain approximately equal amounts of mercury for each treatment. The amount of mercury supplied was 4.25 pounds metallic mercury per acre.

† The percentage of rhizoctonia on the tubers, and the amount of culls were obtained by grading and examining all of the plots from the Hews' farm.

of infection on the tubers, however, was reduced somewhat. The addition of the fungicides did not reduce the number of cull potatoes.

The mercury compounds affected the growth of the plants, causing them to be slightly dwarfed and more erect. Corrosive sublimate and yellow oxide of mercury caused the greatest amount of injury. Zinc-mercury amalgam gave less injury than either corrosive sublimate or yellow oxide of mercury. Calomel caused the least injury to the plants in these tests. It should be noted also that the yields were reduced by the amendments to the fertilizer. The reduction in yield was quite marked in the corrosive sublimate and yellow oxide treatments. Zinc-mercury amalgam and calomel gave slight yield reductions.

Spraying and Dusting Potatoes. Reiner Bonde. The growing season of 1938 was characterized by being especially favorable for the development of late blight or "rust." Wet weather prevailed throughout the entire growing period and Aroostook County experienced one of the most severe blight epidemics in its history. The growers, in spite of an extensive spray program, experienced some difficulty in controlling the disease. The amount of rot caused by the late blight fungus was large and in some cases destroyed from 25 to 30 per cent of the tubers. It was estimated from data secured from potato inspectors located throughout Aroostook County that the loss caused by tuber rot (mostly caused by the late blight fungus) was from 6 to 8 per cent of the entire crop.

It is probable that some of this loss could have been prevented by delaying the digging operations until the vines were dead. Some growers dug their potatoes while green and infected foliage was present. The diseased foliage acted as a source of infection and the tubers were inoculated during the digging operations. The inoculated tubers did not show decay until several weeks later. In some cases the amount of decay that followed was so great that the bins of potatoes settled several feet while in storage.

Comparison of Spray Fungicides. Growers are gradually becoming interested in the new copper fungicides. It would be desirable to obtain a fungicide that is easy to apply and relatively cheap to use. The new fungicide should give good control of diseases and insects. It would be desirable also for this fungicide to leave a colorless residue on the potato foliage. This would facilitate easier roguing of seed plots and fields intended for certification

which is a desirable feature at this time when special emphasis is being given to better seed production.

The severe blight epidemic of 1938 afforded an excellent opportunity to test the relative merits of the different copper fungicides. Table 17 presents the comparative yields obtained in 1937 and 1938 on plots receiving various spray treatments.

TABLE 17

Yield Comparisons of Different Spray Treatments in 1937, a Season with Relatively Little Late Blight, with 1938 when Late Blight Was Very Severe

Fungicide*	Yield per acre		Source
	1937	1938	
	Barrels	Barrels	
Bordeaux mixture	144	143	
Copper Hydro "40"	154	137	Chipman Chemical Co., Bound Brook, N. J.
Bordeaux 34	157	135	General Chemical Co., New York, N. Y.
Basi-cop	154	128	Sherwin-Williams Co., Cleveland, O.
Copper acid phosphate	156	128	Monsanto Chemical Co., St. Louis, Mo.
Copper oxychloride	156	120	E. I. du Pont de Nemours & Co., Grasselli Chemical Dept., Cleveland, O.
Unsprayed controls	126	98	

* The metallic copper content of each fungicide was applied at a concentration which was equal to that in a 10-10-100 bordeaux mixture.

The yield comparisons of the plots treated with various fungicides for the two seasons are very interesting. In 1937, with relatively little late blight, all of the fungicides yielded more than bordeaux. However, in 1938 under extremely severe blight, bordeaux was the most effective of the fungicides.

The data in Table 18 summarize the yields of another experiment in which bordeaux was compared with different copper fungicides in 1938.

In these comparisons, as in the previously mentioned experiment, bordeaux mixture gave superior results. This treatment did not, however, result in a significantly higher yield than the treatment with Cuprocide 54 and Coposil, the difference being only 6 barrels in favor of bordeaux.

COOKING QUALITY OF POTATOES. Marion D. Sweetman. Investigations this year included additional ratings of the mealiness

TABLE 18

Yields for Different Copper Fungicides for the Control of Late Blight in 1938

Fungicide*	Yield rate per acre	Source
	Barrels	
Bordeaux mixture	131±2.97	
Cuprocide 54	125±3.01	Röhm and Haas Co., Philadelphia, Pa.
Coposil	125±3.15	California Spray Chemical Corp., Elizabeth, N. J.
Basic copper	119±2.83	Brooklyne Chemical Works, Inc., Baltimore, Md.
Z–O	112±2.67	Nichols Copper Co., New York, N. Y.
Bonide Fungaloid	96±2.36	Bonide Chemical Co., Inc., Utica, N. Y.
Unsprayed control	74±3.40	

* The copper concentration for each material was equal to 10-10-100 bordeaux.

of potato samples from the Aroostook Farm plots and a few samples from other farms on which fertilizer tests were made.

Fertilizer Tests. Potato series on the permanent plots (variety Green Mountain). The outstanding finding of the year was the marked superiority in mealiness of tubers from plots receiving C.P. salts. In the nitrogen series, there was a perceptible decrease in mealiness when the fertilization level was increased from 4 to 6 per cent. In the potash series, as in previous years, mealiness diminished somewhat above a certain level of application, this year at the 4-8-14 level as compared with the 4-8-10. The 4-0-7 fertilizer produced tubers which were slightly more mealy than the 4-4-7.

Liming had no pronounced effect on cooking quality and it made no marked difference whether the nitrogen and potash were added in the form of sulfate or chloride at the level these were tested.

In borax tests on the Blackstone farm a slightly detrimental effect on mealiness appeared as the rate of application reached 5.0 pounds of borax per acre and was definitely noticeable at the 10 pound level. This did not appear in the borax tests on the Easler farm but all of these tubers were inferior to those from the Blackstone farm except on the Blackstone plot receiving 10 pounds of borax.

The magnesium test on the Emery farm showed no definite effect of the magnesium on cooking quality, but mealiness diminished when the levels of potash rose above 10 per cent. The Cob-

blers grown on the Higgins farm likewise failed to demonstrate any effect of magnesium on mealiness.

In the fertilizer level tests comparing the effects of application of the standard (4-8-7) fertilizer at 0, 2,000 pound and 3,000 pound levels, the four varieties tested produced the mealiest tubers when no fertilizer was applied and the least mealy tubers on the 3,000 pound level except that there was no noticeable difference between Cobblers and Chippewas from the 2,000 pound and 3,000 pound levels. Chippewas receiving no fertilizer were as mealy as Green Mountains receiving the 3,000 pound application. Broadcasting the fertilizer also definitely diminished mealiness.

The fact that the use of C.P. salts does not produce the decrease in mealiness noted when corresponding large applications of the usual fertilizers are made seems to suggest future tests to determine which constituents of the latter are responsible for the detrimental effect.

ROGUING SERVICE FOR PRODUCERS OF FOUNDATION SEED POTATOES. Geddes W. Simpson and Reiner Bonde. Maine growers must produce better seed stocks for the market if they expect to control the seed market in the eastern United States. There is need of a source of reliable foundation seed potatoes for Maine growers. According to E. L. Newdick, 55 per cent of the potatoes entered for seed certification in 1938 were rejected because of having too much disease. The object of this project is to elevate and maintain the quality of the seed potatoes produced in Maine for use in Maine.

The rules and regulations under which the Maine Agricultural Experiment Station will place its seal of approval on foundation seed stocks *for use in Maine only* follow:

Isolation Requirements. Practical experience indicates that mosaic is, over a period of years, the most important virus disease of potatoes in Aroostook County. Outside the County, leafroll assumes greater importance. In order to take this knowledge into consideration in formulating these rules, the varieties have been grouped on the basis of resistance to mosaic. It is believed that less isolation is needed in the case of those varieties that show, under field conditions, some resistance to mosaic. Outside Aroostook County, where leafroll is of major importance, more isolation appears to be necessary.

The grower who wishes to apply for supervision of his seed plot by the Station must be able to meet the following requirements regarding the isolation of his seed plot from other potatoes:

A. North of 45° 30′ north latitude (a line running from Appleton (Somerset County) through Greenville, Winn, and Vanceboro).

Green Mountains Bliss Triumphs	½ mile between seed plot and potatoes not entered in this program. An exception may be made in those cases where fields are planted with seed coming from seed plots in the program, or if the seed planted is eligible for entry in the program (planted by tuber units, sufficiently free from disease to qualify under this program, and rogued as early and over as long a period as the seed plot).
Cobblers Katahdins Chippewas Spaulding Rose Sebago	¼ mile between seed plot and potatoes not entered in this program. An exception may be made in those cases where fields are planted with seed coming from seed plots in the program, or if the seed planted is eligible for entry in the program (planted by tuber units, sufficiently free from disease to qualify under this program, and rogued as early and over as long a period as the seed plot).

B. South of latitude 45° 30′.

A distance of one mile may be required for all varieties in plots outside Aroostook County. Natural barriers, prevailing winds, and other factors bearing on the spread of aphids must be considered.

Care of Land. The land used for the seed plot must be well prepared for planting by the Grower. The Grower must do the necessary amount of hoeing and cultivating. A weedy plot will be automatically disqualified from further consideration. The aphids that spread disease can, in many cases, feed on the weeds that grow in potato fields. The Experiment Station will not be responsible for the care of land but does reserve the right to disqualify a Grower if weeds in the plot interfere with roguing operations or are thick enough to provide a harbor for aphids.

Planting. Planting must be done by the Grower in a careful manner. Planting must be done early. No plot will be considered if planted after May 20th in normal seasons. If a field is normally late, it is not suitable for the purpose of this project. Seed plots shall be completely planted before commercial plantings are made

on the coöperating farm. All planting shall be done by tuber units. When a Grower first enters the program, he must provide seed stocks so sorted that the tubers may be quartered. Skips, equal in length to twice the distance between seed pieces, must be made between units in planting. (Exception:—If a Grower has seed, or can obtain seed early harvested before August 20 from a tuber unit seed plot, he may plant whole tubers and those that can be cut in half, without skips—the rest must be planted with skips. Early harvested seed must be sorted for size and each size planted in a definite area within the seed plot. Stakes must clearly indicate where one size begins and another ends.) Seed plots must be isolated from large fields even though the large fields are planted by tuber units and are in, or eligible to be in, this program. Seed plots of different varieties must be isolated from each other. Green Mountains and Cobblers *must* be treated with corrosive sublimate. Other varieties should be treated.

Spraying. Seed plots must be sprayed, until August 15, with a fungicide that does not discolor the foliage. Bordeaux may be advisable after August 15 if late blight becomes prevalent. Fields infected with late blight to such an extent as to interfere with roguing will be disqualified.

Roguing. The Experiment Station will hire roguers and supervise their work. Roguers will detect and remove diseased units, place them in bags and transport them to the ends of the rows. Roguers will rogue only one row at a time. Roguers will mark all units removed with a stake on which will appear the date and the name of the disease removed. The Station will supply the stakes. The cost of the stakes will be paid out of the fee collected at the time the application is sent in. Roguers will keep an accurate record, apart from the stakes, of diseased plants removed and dates of removal. Roguers will make a map of the seed plot showing the location of all units and indicating those removed because of disease. The date of removal and the name of the disease will be plainly marked on the map.

The Grower must provide some means for the disposal of diseased tops. If barrels are used they must be supplied with burlap bags large enough to cover the top of the barrel. The barrels must be removed *daily* to a point at least as far from the plot as the distance to nearest potatoes not in the program. Waterproof fertilizer bags may be used if barrels are not desired. They must be removed

daily. Disregard of this provision will be cause for disqualification of the seed plot.

Early Harvesting. The roguers, under the supervision of the Experiment Station, will select individual hills for early harvesting in the area of the seed plot selected by the Station staff on the basis of the map provided for above. Roguers will inspect individual hills as dug and separate the seed into two lots on the basis of freedom from rhizoctonia or lack thereof. The Grower will provide necessary labor for pulling of tops and at a later date for the hand digging of individual hills. The Grower will also supply labor for picking up potatoes after the roguers have inspected them for rhizoctonia. It is expected that only enough seed to provide for the planting of the next years' seed plot will be inspected for rhizoctonia.

Storage. The Grower must provide barrels or other approved containers for the storage of early harvested seed. These must be covered, in the field, with burlap. The containers must be clearly marked with the year of harvest. The main crop must be stored in a bin by itself. Early harvested seed should be stored over winter in barrels. (Other methods of storing may be approved but their use without the knowledge and consent of the Experiment Station may be considered sufficient cause in itself for disqualification.)

Disposal of Seed Stock. No seed stock developed and approved by the Station under this program shall be offered for sale outside the State of Maine until such time as the supply of such seed shall exceed the demand for foundation seed in Maine. The Experiment Station reserves the right to refuse further service to any one not complying with this provision.

Florida Test Sample. The Grower is required to take a representative sample from each seed plot at harvest time to be placed in the Florida test. Seed will not be finally approved by the Station unless the returns from the Florida test indicate that the seed meets the requirements for such approval. The Grower's responsibility will be the same for this sampling as was the case for the Florida test for the 1938 crop.

Disease Tolerance. Mosaics, 1 per cent; leafroll, trace; spindle tuber, trace; bacterial wilt, none. If the roguing records indicate that more disease than the above tolerances allow was removed from the seed plot during the summer, the plot will be disqualified. If the amount of disease exceeds the tolerance but slightly, early

harvested seed may be entered, at the discretion of the grower, in the program the following year but the late harvest will not be approved. If the Florida test indicates that there has been spread of disease during the summer to such an extent that the above tolerance will be exceeded if the stock is planted, said stock will not be approved. (In view of the acute seed stock situation some leeway may be allowable for virus diseases for the *1939 season only* but in no case beyond 2.5 per cent for all viruses mentioned above. Chances of success with more disease are greatly reduced.)

Special Rule on Seed Sources for 1939 and for Those Who May Enter at a Date Later Than 1939. At the start of this program special restrictions on seed sources and size of plot must be made. Unless seed early harvested from *rogued tuber-unit plots* before August 20 is available for planting in the first instance, the seed plot must be restricted to 5 acres or less, and the plots over 1 acre in size must be planted from Florida tested seed stock with a disease reading of not over 2.0 per cent or the equivalent of such stock. Further, with plots over an acre in size and planted from seed not early harvested the Station reserves the right to disqualify and abandon such plots at any time their success becomes doubtful.

When early harvested seed is available, the size of the seed plot will be limited only by the amount of such seed. Seed harvested at the end of the season from a tuber-unit plot planted with early harvested seed may be used to plant larger tuber-unit fields that may be entered in this program provided they are so situated as to comply with distance rulings and are free enough from disease to meet the tolerance requirements. Plots larger than an acre (except under certain conditions stated above applying to the first year a grower enters this program) must be planted with early harvested seed or seed harvested at the usual time from a tuber-unit plot planted with early harvested seed. Except for the year of entry into this program, no seed plot will be accepted from a grower unless planted with seed early harvested from a tuber-unit plot.

Financial Arrangements. Growers will deposit $15.00 per acre at time of application. No application will be received after April 1 in any year. Adjustments up or down may be made June first to the extent of 10 per cent of the acreage mentioned in the application. If advantage is taken of the right to adjust acreage figures to the extent of 10 per cent of the figure in the application, a deposit covering the additional acreage must accompany the

request to change the acreage figure. If the acreage is less than that requested in the application, a refund will be made. This refund will be made only on that part of the acreage that comes within 10 per cent of the original figure. No refund can be made for plots that may not qualify on distance or disease content or that are rejected for other reasons. No refund, other than that mentioned above, can be made after applications have been accepted on April 1. Growers must provide satisfactory room and board for the roguers or provide transportation to and from work or make satisfactory financial arrangements with the roguers to cover these costs.

The Experiment Station will collect funds in advance and handle all salaries and other expenses connected with roguing except those specifically delegated to the Grower. Refunds will be made if money collected exceeds expense.

The Station will render a financial report to all coöperators at the end of the season.

General. In order to provide for 1940 plots the Grower must indicate in his application maximum seed plot acreage desired in 1940 so that adequate provision can be made for early harvesting sufficient seed to meet that need.

The Experiment Station staff in charge of this program appreciate fully the strictness of the program and the difficulties that may be encountered in qualifying in 1939 so far as disease-free stock is concerned. They are willing to coöperate in every way possible and to make concessions in the regulations outlined above if such concessions are not such as to defeat the purpose of the program. The whole object of the program is to provide technically trained and supervised aid in the development of Foundation Seed Stock. Every rule or regulation included is for a very definite purpose and is based on the experience of Station workers in actually developing high-class seed stock. The Station will exercise all possible care in carrying out its end of the program but cannot be responsible for failure in individual cases due to unfavorable natural surroundings or to insect outbreaks.

Potato By-Products. Charles A. Brautlecht. Information is being accumulated regarding white potato products of economic value. White potato starch is, by far, the most important of the potato products. The most important development during the period considered was the building of two new modern starch factories in Houlton. George Lundy also built a small old-type factory at

Grand Isle. The New England Starch Company built a modern factory in Houlton with a greater capacity than any other in Aroostook. This new factory began operations early in January and is producing a quality of starch which is better than that made at any of their other nine factories.

The Aroostook Potato Products, Inc. (A.P.P.) a subsidiary of Morningstar, Nicol, Inc., of New York, also built a new modern starch factory in Houlton, adaptable to making starch and other potato products. They began operations early in February of 1939. The A.P.P. factory has a capacity of about 12 tons of starch per day with a moisture content of seventeen per cent whereas the New England factory has a capacity of about 18 tons. Naturally this means increased competition for culls in this district. A.P.P. has a railroad siding so that some potatoes can be brought in from districts where no starch factories exist. This factory is the only one where potatoes can be moved from a freight car directly to a potato cellar without rehandling. A.P.P. is making a quality of potato starch which is about the equal of the better grades of imported starch. The A.P.P. factory is equipped also to make the highest quality white potato dextrin which will be the first dextrin made commercially in Maine.

Analytical Results. Methods of examining starch and potatoes have been studied further with some improvement in procedures. Several analyses were made with comments, in the potato products year 1937-1938 as follows:

	Samples
Fermented starch	3
Starch, pearl	4
Starch, powdered	10
Specks from starch vats	2
Wet pulp from screens	3
Potatoes, experimental for starch content	12
Imported potato starch	1
Starch vat liquor	1
Potatoes, factory	8

In addition to the starch samples referred to above, the factory and experimental potatoes were grated in their own water, starch was extracted, and quality thereof examined. Mineral constituents were determined in the experimental potatoes.

During the first half of the 1938-1939 potato products season, the following analyses were made:

	Samples
Starch, pearl	1
Starch, powdered	4
Pulp from starch screens	1
Potatoes, factory, for starch content	7
Imported starch, powdered	1
Water for starch making	1
Starch in experimental potatoes	14

In almost all cases, potato starch was examined for moisture, starch content, viscosity, granule size, ash, paste quality, sulfur, acid, specks, and sieve test.

In the examination of both potatoes used in starch factories and experimental potatoes, total carbohydrate (which represents almost entirely starch) has been determined in Green Mountains, Cobblers, Chippewas, Rurals, Sebagos, and Houmas. Experimental and factory potatoes yielded the following results:

Variety	Fertilizer per acre	1937 crop	1938 crop
Green Mountains	None directly	17.0	17.7
	1 ton	16.4	15.4
	1½ tons	16.1	13.7
Cobblers	None directly	16.5	16.0
	1 ton	15.6	13.5
	1½ tons	15.2	13.4
Chippewas	None directly	17.0	13.1
	1 ton	14.5	10.6
	1½ tons	13.8	9.5
Rurals	None directly	19.1	16.6
	1 ton	17.0	14.5
	1½ tons	15.2	13.4
Sebagos	1 ton	—	12.5
Houma	1 ton	—	14.3
Factory Potatoes—Mixtures, mostly of Green Mountains		8 samples 11.5-16.2	7 samples 11.2-14.3

Baking tests by Dr. Marion Sweetman confirmed the general impression "the higher the starch, the better the baking qualities."

Some cooking tests, for flavor, also indicated that the samples with higher starch content were better flavored and that high starch content does not affect potato flavor adversely. A marked deviation from normal in ash or nitrogen content is reported by some investigators as influencing flavor.

Weather conditions influence composition of potatoes. For example, in a normal year, starch content of Green Mountains is about 16 per cent. In a wet year such as 1938, starch content averages less. In a good potato year with large yields, starch content may reach 19 to 20 per cent. Mineral salt content also is affected. In general, it can be stated that the bigger the crop and the better the growing conditions, the higher the starch content and the better the starch yield in starch factories. Green Mountains yield the most and the best quality starch. Culls and No. 2's going into starch factories during the period under consideration, contained, as an average, about 13.5 per cent starch. With a smaller 1938 potato crop, much of which was dug wet, more dirt adhered to the potatoes going into starch factories, the limits being 0.2 and 0.9 per cent. With a daily starch production capacity now of about 160 tons, against less than 75 tons in 1934, if the present average starch quality is maintained, potatoes need never be dumped again in Aroostook County, as they were in 1935. The Bangor and Aroostook Railroad Company report indicated 6,380 tons of potato starch were shipped in 1937 and 7,396 tons in 1938.

Sulfur Dioxide. Since the first use of sulfur dioxide at the Higgins and Lenfest factory in Mapleton, in October, 1937, its use has spread so that at least eighty per cent of Maine starch is made with its use, it being introduced usually at the rasp or at the sieve sump. It has aided in improving quality (quality improvement being recognized on the New York starch market), helped to improve the price of potato starch, increased yield slightly, and helped to reduce production costs. Its use will undoubtedly be further increased until all factories use it. In furnishing sulfur dioxide in small steel cylinders to Lenfest and Higgins, different quantities were tried out and it was found that from ½ pound to 1 pound of sulfur dioxide per ton of finished starch was a satisfactory quantity. Delivered price of sulfur dioxide in Aroostook is about 9 cents per pound and cost per ton is very slight for the improvements obtained. Examination of several samples of finished starch made with the use of sulfur dioxide has never shown even a trace of sulfur. Due

to the absorptive properties of starch, impurities readily adhere to starch granules. Penobscot County Water Company water is not well suited for making the highest quality starch due to organic colored impurities which are adsorbed.

Starch Uses. One new use for domestic white potato starch, replacing the imported is in calico printing. Domestic white potato starch now (March, 1939) sells on the New York market at 4 to 5 cents per pound and the imported sells at 5 to 6 cents per pound. The freight cost to New York and Boston is about ½ cent per pound. The sales commission is usually figured at ¼ cent per pound. Some of the poorer quality domestic potato starch sold for 2 cents per pound during the present as in past seasons. When only 2 cents per pound is offered, starch makers feel that they cannot afford to pay over 10 or 15 cents per barrel for culls. Potato dextrin is now quoted at 7 to 7¾ cents per pound. There is some loss in material in conversion of starch into dextrin. The chief use for white potato starch is in sizing fine count warp threads in the cotton textile industry. There are many other uses. The paper industry has shown interest in the starch produced in the new factories.

Starch Production. The quantity of starch produced from the 1938 crop will probably represent a consumption of about 3,500,000 to 4,000,000 bushels of culls and No. 2's. With the better quality of starch that is produced at some of the factories, and a good market, a greater supply of potatoes could be used at these factories. It is probable that factories that cannot obtain more than 2 cents per pound, f.o.b. Aroostook, for their starch and which can only pay 10 or 15 cents per barrel for culls will be obliged to give way, eventually, to others, that will pay more for their raw material.

BULK VERSUS BOX STORAGE OF POTATOES. E. C. Meyer. The study consisted in obtaining information concerning bulk and box-stored potatoes in a trackside storage at Presque Isle, Maine. Katahdin potatoes were used. One thousand eight hundred and twenty-six boxes (107,551 pounds) were stored in one bin and 90,125 pounds (bulk) in another. Both bins were completely filled, the height being approximately 12 feet. The bulk bin was 18¾ feet long and 9¾ feet wide. The potatoes were placed in the storage from October 15 to 20, 1938. The bulk bin was emptied, beginning on January 6, 1939.

Potato temperatures during storage were measured by the use of thermocouples distributed throughout both bins; air tem-

perature immediately below and above bins by thermocouples; and relative humidity above the potatoes by recording hygrothermographs. Outside air temperatures were taken and inside relative humidity checked by means of a sling psychrometer. Readings were taken each day during the time of storage except Sundays. The comparative figures for grades at the time of removal of the potatoes were as follows:

Box stored		
U. S. Fancy No. 1	73,000 pounds	73.4 per cent
Pickouts	14,805	14.8
Peas and Seconds	9,083	9.0
Dirt	2,841	2.8
	99,729	100.0
Bulk stored		
U. S. Fancy No. 1	63,900 pounds	75.2 per cent
Pickouts	9,646	11.3
Peas and Seconds	8,284	9.7
Dirt	3,311	3.8
	85,141	100.0

According to the grading results there were 1.8 per cent more U. S. Fancy No. 1 potatoes in the bulk than in the box stored. This is contrary to what might normally be expected since bulk stored potatoes are handled more and therefore subject to more bruising.

The box-stored potatoes showed a slightly greater shrinkage in storage than did the bulk stored. Figures for shrinkage are as follows:

Box stored	7.3 per cent
Bulk stored	5.5 per cent
Difference in favor of bulk—1.8 per cent	

Since the U. S. Fancy No. 1 potatoes constitute three-fourths of the total most of the shrink would occur in this group. The difference in percentage of shrink is exactly equal to the advantage which the bulk stored potatoes, in this test, had so far as grading is concerned. If the shrinkage in both bins had been the same, there would have been little difference in the grading percentage in this particular experiment.

Average temperature conditions during the period of November 11, 1938, to January 6, 1939, were as follows:

	Bulk	Box
Air temperature immediately above potatoes	46.3	45.2
Temperature at center of bins	46.4	44.5
Air temperature immediately below bins	45.2	44.4

The air temperature below the two bins was quite uniform through the entire period, in some cases one being a bit higher and in other cases the other being higher. This was probably due to variations in the opening of doors, windows, and direction of wind.

During the period from November 11 to December 3 there was a greater difference between bulk and box bins so far as temperature at the center of bins and above was concerned:

	Bulk	Box
Air temperature immediately above potatoes	48.7	45.5
Temperature at center of bins	48.3	45.3

During the remainder of the storage period, namely, from December 3 to January 6, the average temperatures were:

	Bulk	Box
Air temperature immediately above bins	44.8	45.0
Temperature at center of bins	44.7	43.8

The greater temperature differences during the early storage period might readily be expected since the heat generated during this period cannot be liberated as effectively in the tightly packed bulk bins.

Hygrothermographs were installed immediately above the potatoes on November 22 and the average relative humidities during the storage period were as follows:

Bulk bin—88.5 per cent Box bin—91.7 per cent

This difference in relative humidity can be accounted for entirely as a result of the difference in temperature existing above

the potatoes where the instruments were located. A Psychrometric Chart will show that air with a relative humidity of 88.5 per cent and a dry bulb temperature of 46.3 carries the same number of grains of moisture per cubic foot as air with a relative humidity of 91.7 with a temperature of 45.2 degrees F.

Since Katahdin potatoes were used in this experiment, it might be expected that there would be little difference in the grading. If the same standards were used in this grading there seems to be no reason for the results favoring bulk-stored potatoes since the operations subject them to more severe treatment.

In the matter of shrinkage, the box-stored potatoes might show a greater loss, even though the air surrounding them had a higher relative humidity, because of the greater amount of air circulating through them and carrying with it moisture from the potatoes.

Paring waste studies were made by the Department of Home Economics. Potatoes stored in bulk bins showed a waste of 8.90 per cent and those stored in boxes a waste of 7.95 per cent. On the basis of these figures, the food-dollar value of the box-stored potatoes was only 1.05 per cent greater than that of the ordinary bulk-stored product. This study was made with Katahdin potatoes which are smooth and apparently less subject to injury from handling than is the Green Mountain variety.

SMALL FRUITS

BLUEBERRY INVESTIGATIONS. Frederick B. Chandler and Irvin C. Mason. *Fertilizers.* None of the fertilizer plots were in fruit during 1938, therefore no information is available beyond that presented in Bulletin 391. The data from the plots which received lime indicate that lime is beneficial. An abstract of a paper on the effect of lime on the low-bush blueberry will be found in the back of this bulletin in the section on Publications.

Vegetative Propagation. The use of growth substances has not increased the rooting of blueberry cuttings sufficiently to justify their use under the conditions of the investigations made so far. Further studies will be made to study the type of wood best suited for propagation.

Breeding. In the spring of 1939 more crosses were made in the greenhouse, and a few crosses were made in the field. Cabot,

one of the successful varieties, has been selfed and the progeny back crossed with Cabot. The testing area at Highmoor Farm was increased this year to accommodate the new seedling.

Fruitfulness. The results of pollination studies in 1938 showed that honeybees were essential for a good set of fruit. The percentage set of fruit from plants exposed to visits of wild bees appears to be decreasing gradually and in some sections is as low as 15 per cent. A good set of fruit is about 50 per cent and with honeybees in the fields in a few cases over 60 per cent set has been obtained. Honeybees will not produce large quantities of honey in the blueberry area but they will produce enough to pay for the cost of the necessary equipment. Package bees are not as satisfactory as strong colonies of bees that have been carried through the winter. During the winter honeybees should be packed with shavings and kept outdoors. The winter packing should be put on the first of November leaving a chance for the bees to fly out on warm days. The packing should be removed in April. Strong colonies should have new queens every two years to keep the colony large and with only a few drones.

Weed Control. Considerable attention has been given to the woody weeds which grow rapidly and thus shade the blueberries. Another chemical analysis of the creeping rootstocks of sweet fern shows that the storage is lowest during July and early August (the time recommended to cut sweet fern for the best control). Studies on the cutting of common willow, *Salix* sp., at different times of the year for the past three years has not revealed any practical method of control. The application of common salt to the surface of the stump after cutting appears to be a practical method of controlling the common willow. None of the cuttings of hardhack, *Spiraea lalifolia* Borkh., made at intervals over several months showed satisfactory control.

A patented herbicide, Dolge Weed Killer, was applied to woody and herbaceous plants last season. It was found necessary to make two applications of this weed killer to eradicate poison ivy or cinquefoil.

Blueberry Insects. Frank H. Lathrop. Studies of the biology and control of the blueberry fruit fly and the blueberry thrips were continued during the year 1938-1939.

Blueberry Fruit Fly (*Rhagoletis pomonella* Walsh). Studies of non-arsenical dusts for the control of the blueberry fruit fly were

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continued. During the summer of 1938, ten acres of blueberry land was dusted with a dust consisting of a mixture of derris dust and pulverized clay, the mixture containing 2 per cent rotenone.

An adjoining plot of ten acres was dusted with calcium arsenate.

Two applications were made of both the rotenone dust and the calcium arsenate. The treatments were applied on July 14 and July 24. A horse-drawn, power-driven duster was used, and the dust was applied at the rate of approximately 6 pounds per acre at each application.

Samples of fruit examined at picking time showed that on the plot dusted with rotenone there was an average of 17 fruit fly larvae per 20 ounces of berries. On the plot dusted with calcium arsenate there was an average of 7 larvae per 20 ounces of berries.

Compared with the results obtained in 1937, the rotenone dust was somewhat disappointing in 1938. Possibly the comparatively unsatisfactory results may have been due in part to more frequent rains in 1938. The blueberry plants dusted with rotenone appeared to retain their foliage more completely than did the plants dusted with calcium arsenate.

The Blueberry Thrips (*Frankliniella vaccinii* Morgan). The continued cold weather in the spring of 1939 seemed especially favorable for the development of the blueberry thrips. Infestation on the experimental plots in Cumberland County, near Brunswick, seemed more severe than it was during past years. There was also a noticeable increase in thrips injury in parts of Washington County where in past years the injury was of little or no consequence.

Because of the thoroughly unsatisfactory results secured from the use of insecticides in the experiments conducted during the past few years, attention was turned to a study of burning in 1938-1939. It had been recommended[42] previously that the infested areas should be burned over about the middle of June. As a substitute for burning, some growers had tried picking the thrips-infested leaf clusters during early summer.

To test the effectiveness of picking the leaf clusters and burning over the infested land the following treatments were applied to plots (each plot ten feet square) of heavily infested plants.

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[42] Phipps, C. R., Blueberry and Huckleberry Insects, Maine Agr. Expt. Station, Bul. 356, p. 128, 1930.

June 13. One plot burned over.
June 29. Infested leaf clusters from one plot picked and dropped to the ground.
June 29. Infested leaf clusters from one plot picked and removed from the area.
July 6. Infested leaf clusters from one plot picked and dropped to the ground.
July 6. Infested leaf clusters from one plot picked and removed from the area.
July 8. Two plots burned over.
July 20. One plot burned over.
July 28. One plot burned over.

In burning over the plots a kerosene torch was used. The torch is similar to the apparatus often recommended for burning weeds.

It is too early to draw final conclusions from the work. The treatments do not appear as promising as had been hoped. Picking the infested leaf clusters is slow, tedious work that would probably be expensive if employed on a large scale.

It was found to be difficult to burn the thrips-infested leaf clusters. At first it was considered satisfactory if the leaf clusters were thoroughly burned on the outside. It was soon found, however, that thrips survived the treatment even though the leaf clusters were severely burned on the outside. It became evident that it would be necessary to reduce the infested leaf clusters practically to ash before all of the thrips were killed. Such thorough burning of the green plants is slow, difficult, and therefore expensive work.

In the spring of 1939 the plants on many of the plots showed distinct injury as a result of the burning during the preceding summer.

On most of the plots the result of the treatment seemed unsatisfactory, whether the leaf clusters were picked or were burned, and in the spring of 1939 there was general reinfestation on the treated plots. It has not yet been determined whether the reinfestation of the treated plots resulted from movement of the thrips from adjoining, untreated areas, or from a carry-over of thrips that may lie dormant in the soil till the second summer.

STRAWBERRY BREEDING. Russell M. Bailey and Iva M. Burgess. Some breeding work with the strawberry is in progress. One

hundred and twenty-five selections made from crosses involving Howard 17, Aberdeen, Fairfax, Blakemore, and Big Joe as parental varieties are under study at present.

MISCELLANEOUS

MOSQUITOES COLLECTED IN MAINE. Frank H. Lathrop. During recent years there has been an increasing interest in the mosquitoes of Maine, especially from the standpoint of communities in which the residents are anxious to do something about the mosquito nuisance. In any attempt to reduce the mosquito population in a locality, it is first of all desirable to know what species are to be combated.

To accumulate information concerning the mosquitoes that occur in the State, collections were made in 1938, and it is hoped that collecting may be continued until a fairly complete list can be compiled.

The collections in 1938 were made by Professor C. O. Dirks, Doctor J. H. Hawkins, Mr. Edward King, Doctor F. H. Lathrop, Mr. John Reed, and Doctor G. W. Simpson. Responsibility for the records in the following list is indicated by initials in parentheses. Records of several species were published[43, 44, 45] in past years by Doctor Edith M. Patch and Doctor O. A. Johannsen. Their records are included in the list and indicated by references to their respective papers.

The species (except those indicated by citations to literature) were identified by Doctor Alan Stone, through the courtesy of Doctor F. C. Bishopp, Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture.

The list of species follows:

Anopheles maculipennis Mg.
Aroostook County, May 25-30 (G.W.S.)
Anopheles punctipennis (Say)
Presque Isle, May 8 (G.W.S.); Orono, July 27,[43] Oct. 1.[43]
[43]*Anopheles quadrimaculatus* (Say)
Orono, Sept. 20.[43]

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[43] Patch: Maine Agr. Expt. Sta. Bul. 134, 1906 (p. 225).

[44]*Aedes atropalpus* Coq.
Orono, "During the summer" (?);[45] Stillwater branch of the Penobscot River, Sept. 22.[44]

Aedes canadensis (Theob.)
Aroostook County, May 25-30 (G.W.S.); Brunswick, June 21 (F.H.L.); Caribou, Aug. 17;[43] Trenton, Aug. 10.[43]

Aedes cinerus Mg.
Brunswick, June 21 (F.H.L.); Harrington, Aug. 8 (F.H.L.); Orono, June 9 (C.O.D.), June 13 (C.O.D.), July 27.[43]

Aedes fitchii (F. & Y.)
Monmouth, June 2 (F.H.L.); July 4 (F.H.L.); Orono, June 9 (C.O.D.), June 13 (C.O.D.), June 25 (C.O.D.); Unity, June 28 (J.R.); Wells, Aug. 3 (F.H.L.).

Aedes sollicitans (Walk.)
Brunswick, June 21 (F.H.L.); Harrington, Aug. 8 (F.H.L.); Trenton, Aug. 10;[43] Wells, Aug. 3 (F.H.L.).

Aedes stimulans (Walk.)
Brunswick, June 21 (F.H.L.); Orono (?).[45]

Aedes trichurus (Dyar).
Aroostook County, May 25-30 (G.W.S.); Orono, June 13 (C.O.D.), "May and early June."[45]

Aedes vexans (Mg.)
Harrington, Aug. 8 (F.H.L.); Trenton, Aug. 10.[43]

[44]*Culex apicalis* Adams
Orono, Dec. 17,[44] Dec. 21.[44]

Culex pipiens Linn.
Orono, Aug. 4 (E.K.), Aug. 8 (E.K.), "...still prevalent in October."[45]

Culex restuans Theob.
Southern Penobscot County, Oct. 9 (F.H.L.)

Mansonia perturbans (Walk.)
Monmouth, June 2 (F.H.L.), July 4 (F.H.L.), July 17 (F.H.L.).

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[44] Johannsen: Maine Agr. Expt. Sta. Bul. 177, 1910 (p. 36).
[45] Johannsen and Patch: Maine Agr. Expt. Sta. Bul. 195, 1911 (p. 237).

ANNOUNCEMENTS

Mr. John T. Gyger, Board of Trustees representative on the Station Council, died June 1, 1939. Mr. Gyger had taken an active interest in the affairs of the Station and the absence of his counsel will be keenly felt.

Mr. Vincent W. Canham was elected to the Station Council to succeed Mr. Allison P. Howes as representative of the State Grange.

Mr. Fred B. Chandler, Associate Physiologist, was granted the degree of Doctor of Philosophy from the University of Maryland in June 1939.

Mr. William B. Ennis was appointed to the Maine Canners' Association Fellowship for the year 1939-1940. Mr. Ennis is a graduate of the University of Tennessee, class of 1939.

Miss Joan H. Stacy was appointed Assistant in Biology, appointment effective July 1, 1939. Miss Stacy is a graduate of Smith College, class of 1937.

The University has purchased a farm for the Station in connection with Aroostook Farm at Presque Isle. The farm is known as the Annis farm consisting of slightly over 100 acres abutting Aroostook Farm on the north. Approximately 50 acres of this farm are at present available for potato growing, the balance being in woods. Some of the land now in woods will be suitable for potato growing when it is cleared. This additional land will provide a total plowable area sufficient to permit the shifting of the rotation from a two-year to a three-year basis. The house that is on the farm will be renovated and will provide two apartments for staff members living at Presque Isle during the summer months.

PUBLICATIONS

The Station is organized so that the work of investigation is distinct from the work of inspection. The results of investigation are published in the bulletins of the Station and in scientific journals, both foreign and domestic. The bulletins for the year make up the annual report. The results of the work of inspection are printed in publications known as Official Inspections. These are paged independently of the bulletins and may be bound with the annual report as an appendix thereto. Miscellaneous publications, consisting of newspaper notices of bulletins and newspaper articles which are not paged consecutively and for the most part are not included in the annual report, also are issued during the year.

Bulletins Issued in 1938-1939

No. 392. Costs and Returns in Producing Potatoes in Central Maine. 35 pages.
No. 393. Food-Plant Catalogue of the Aphids of the World. Including the Phylloxeridae. 398 pages.
No. 394. Performance Analysis of Selected Types of Kerosene Stoves. 90 pages.
No. 395. An Economic Study of Milk Distribution in Maine Markets. 152 pages.
No. 396. Bacterial Wilt and Soft Rot of the Potato in Maine. 20 pages.
No. 397. Report of Progress for Year Ending June 30, 1939. 151 pages.

Official Inspections Issued in 1938-1939

No. 168. Commercial Feeding Stuffs, 1937-1938. 38 pages.
No. 169. Commercial Fertilizers, 1938. 52 pages.
No. 170. Commercial Agricultural Seeds, 1938. 30 pages.
No. 171. Foods and Drugs. 63 pages.

Miscellaneous Publications Issued in 1938-1939

No. 554. Maine No. 2. A Scab Resistant Home Garden Cucumber.
No. 555. The Control of Insect Pests in Maine Apple Orchards.
No. 556. White Grubs. Destructive Crop Pests in Maine.
No. 557. Vegetable Variety Trials, 1938.

ABSTRACTS OF PAPERS PUBLISHED BY THE STATION IN 1938-1939 BUT NOT INCLUDED IN THE BULLETINS

A complete list of all the bulletins issued by and from the Station in 1938-1939 is given on page 831 of this Report. The following pages contain abstracts of the papers published during the year and not included in the Bulletins or Official Inspections.

VITAMIN C AND LIGHT*

In the course of investigations at the Maine Agricultural Experiment Station upon the vitamin C content of apples during 1936, an effect of light has manifested itself which may be of interest to workers engaged in determining the origin and distribution of vitamin C.

It has been found that the "sunny" side of the apple contains larger amounts of vitamin C than the "shady" side, as determined by the titrimetric method as modified by Bessey and King using 2, 6-dichlorophenol indophenol.

Fifty pairs of tests were completed using nine varieties of apples. Of these 50 pairs of analyses, the results were divided into three groups. The mean differences were computed by Student's method.

(a) Eighteen pairs of determinations on comparable peeled samples of apples.

The ascorbic acid content of the "sunny" side exceeded that of the "shady" side in 15 of the 18 pairs of tests. The mean difference in ascorbic acid value was $.0150 \pm .0022$ mg/gm with odds of 6,498 to 1 that the difference was significant.

(b) Eleven pairs of determinations on unpeeled comparable samples.

The ascorbic acid content of the "sunny" side was greater than that of the "shady" side in 10 of the 11 pairs of analyses. The mean difference was $.0252 \pm .0028$ mg/gm with odds of 9,999 to 1 that the difference was significant.

(c) Twenty-one pairs of determinations comparing the peeled "sunny" with the unpeeled "shady" side of the same apple.

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* This is an abstract of a paper by Elizabeth Murphy, having the same title and published in Proc. Amer. Soc. Hort. Sci. 36:498-499. 1938.

See p. 273.

The ascorbic acid content of the "sunny" side was higher than that of the "shady" side in 17 of the 21 pairs of analyses. The mean difference was .0139±.0022 mg/gm with odds of 3.145 to 1 that the difference was not due to chance alone. Obviously light exerts an influence powerful enough to overshadow the fairly large reported differences between the peripheral portion and the central portion of the apple.

It is possible that this variation within the same fruit partially accounts for the lack of agreement frequently noted in published data on the vitamin C content of a given fruit or vegetable.

THE NEEDS OF SUPERIOR INDIVIDUALS AS GUIDES TO GROUP ASCENDANCE*

I. An Experimental Approach to the Problem of "Optimum Environment"

II. Population Changes in Relation to Need-Satisfactants: Characteristics and Patterns of the Needs of the Aggridant

The theory of Aggrid ascendance—a theory utilizing the combined positive elements of both the innate and the acquired, of both evolution and conditionability and derived from the need-patterns of the aggridant (the superior) type, is developed in terms, (1) of nutritional need-satisfaction in relation to inter-individual growth rates of experimental animals, and (2) of economic need-satisfaction in relation to inter-individual town population growth rates. The aggridant, whether for individual organism or for town, is represented as a type situated between the mean and the maximum of the group array of individual units differing serially in growth rate. At this locus the following patterns and characteristics of need satisfactants are indicated as clues for the transference of aggridant superiority to other groups:

1. The E-C *P*attern: The aggridant is against both over-*E*xtension and over-*C*ontraction in numbers of different satisfactants.
2. The S-D *P*attern: With an optimum number of satisfactants supplied by the E-C Pattern, the aggridant pattern of needs

* This is an abstract of papers by W. Franklin Dove published in the Jour. of Heredity. No. I is in Vol. 30:4:157-163, April, 1939. No. II is in Vol. 30, in press.

is against the over-*S*pecialization of the maxima and equally opposed to the over-*D*iversification of the minima.

3. *Quantitative* limits are indicated for bulk in digestion and for production rate in commodities.
4. *Qualitative* factors are weighed by their effective need-satisfying values.
5. *Order of acceptance* of satisfactants, together with their combinational and interactive values, are implied in aggridant needs.
6. *Mechanical factors* which may facilitate or retard need-satisfaction are automatically included or disregarded by the aggridant.

NOT BY GENES ALONE*

An attempt is made to reinterpret the genetics of growth, disease resistance, longevity and efficiency in the utilization of food, in terms of *nutritional behavior*. This method of experimentation (Amer. Nat. 69) succeeds again in differentiating genetic modifiers from those of a psychological or of an economic nature. It is found that psychological factors, such as imitation, dominance-submission, social facilitation and greed versus need, affects, significantly, the phenotypic expression through the medium of nutritional behavior. However, the principal modifier of biological functioning, extraneous to genes, appears to be the *socioeconomic system* as it aids or interferes with the *mode of production* and the *method of distribution* of the food required for the optimum genetic expression sought by the geneticist and the eugenicist as "superior germ plasm."—At present, without an economics of production-for-use, superior germ plasm quickly reverts to "scrub" germ plasm...especially in outlying, marginal and soil-depleted regions. Here, genes are submerged by economic factors. Under these circumstances, the search for "superior germ plasm" should be redirected toward the establishment of an economic basis upon which superior germ plasm may thrive.—Observation on the nutritional behavior of phenotypically superior individuals indicates certain economic adjustments necessary for the sustenance of group superiority. An important economic adjustment and a clue to the maintenance of group pheno-

* This is an abstract of Paper No. 228 from the Biol. Lab., Me. Agr. Exp. Sta., presented at the 1938 meetings of the Genetics Soc. of Amer., A.A.A.S. Richmond, Va. Dec. 29, 1938. Genetics 24:69. Jan. 1939.

typic superiority is indicated by the aggridant (the superior type integrated from the group) as an adoption of the bioeconomic Specialization-Diversification Pattern. Through encouragements or pressures, the S-D patterns of the aggridant could be applied to food-production programs so as to ensure an economic and environmental milieu for the support of an otherwise elusive "superior germ plasm."

A Study of Individual Versus Group Needs as a Theoretical and an Experimental Approach to Aggridascendance*

From statistical analysis of the nutritional needs of all individuals of the group, the following observations have been made: (1) That preferences for foods are, in part, individual and, in part, group manifestations of nutritional needs. (2) That when the group is treated as an ever-shifting population of rated individuals, the optimum *group* manifestations of nutritional needs (for growth) are similar to those of the *individuals* who have been rated during the period of growth to lie between the mean and the maximum for rate of growth. Since this position in the group array represents an ever-shifting series of different individuals, a *type* is indicated. And, since the type is integrated from individual (*id*) likeness-differences of all individuals of the group (*aggregate*), the superior, or leader, type has been called the *aggridant* type—an individual type integrated from the group as a whole. (3) That the aggridant type predetermines, specifically, which satisfactants, which ratios, and which quantities of satisfactants are necessary for group superiority. By following the desires of the aggridant, we have uncovered new food combinations which produce a growth rate as much as 30 per cent above standard. (4) That the theory of aggridascendance is applicable also to the satisfaction of needs in general: to the planning of food-production programs, for instance, and to the analysis of needs inherent in the socioeconomic structure. One tangible common denominator derived from these experiments is expressed by the aggridant in a specialization-diversification ratio. This S-D

* This is an abstract of Paper No. 224 from the Biol. Lab., Me. Agr. Exp. Sta., presented at the 1938 summer meetings of the Genetics Soc. of Amer., Marine Biol. Lab., Woods Hole, Mass. 3 Sept. 1938. Genetics 24:98. Jan. 1939.

pattern of the aggridant type is one of the principal clues to a controlled phenogenesis—to aggridascendance.

THE EFFECT OF LIME ON THE LOW-BUSH BLUEBERRY*

Lime was applied to blueberry plots at the rates of 1, 2, 3, or 6 tons per acre. These applications were made once, twice or thrice. In eleven out of the twelve treatments lime gave an increase in yield. Soil samples of the top inch from plots receiving the heaviest application are alkaline. Composite samples of the top 6 inches show that the heaviest lime application (a total of 18 tons) has changed the pH from about 5.0 to 6.6.

THE RELATION OF THE PERICARP TO TENDERNESS IN SWEET CORN†

In a study of the relation of the pericarp to tenderness in sweet corn, two hybrids, two inbred lines, and an open pollinated variety were studied for varietal differences in tenderness, pericarp thickness, and pericarp development during successive stages of development. Tenderness was determined by means of a specially designed machine which measures the resistance of the pericarp to puncture. Histological sections of kernels were studied in order to correlate cell developmental changes with different degrees of resistance to pericarp puncture. The pericarp decreases in thickness as the kernel matures. On the other hand, resistance to mechanical puncture markedly increases with advancing maturity. Varietal differences in tenderness and pericarp thickness were found to exist. The varieties with the lowest puncture index at a given stage of maturity were, in general, those with the thinnest pericarp.

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* This is an abstract of a paper by F. B. Chandler having the same title and published in Proceedings of the Amer. Soc. for Hort. Sci. 36:477. 1938.

† This is an abstract of a paper by D. M. Bailey and R. M. Bailey having the same title and published in the Proceedings of the Amer. Soc. for Hort. Sci. 36:555-559. 1938.

Progress in Breeding Cucumbers Resistant to Scab (*Cladosporium cucumerinum*)*

Seventy-five cucumber varieties and introductions of *Cucumis sativus* from America, England, Germany, Brazil, India, and Turkey have been subjected to artificial inoculation tests for resistance to scab (*Cladosporium cucumerinum*). Significant resistance has been found only in inbred lines developed at the Maine Station and which originated from Longfellow and Windemoor Wonder varieties. Genetic study of populations segregating for resistance indicates that a single factor explains the major degree of resistance and that there may be secondary factors which influence to some extent the degree of resistance. Possibility of the occurrence of physiologic strains of scab has received attention, but laboratory studies and coöperative tests with growers have failed to demonstrate the presence of these in Maine.

Buying and Using Kerosene Stoves†

A popular treatment of the features of kerosene stove construction and use, a part of which includes the general results obtained in the study of kerosene stoves made by the Home Economics Department of the Maine Agricultural Experiment Station.

Observations on the Prevalence of Potato Diseases in Maine During 1938‡

This paper summarizes briefly the losses caused by certain potato diseases in Aroostook County in 1938. Leafroll and mosaic were very prevalent in some fields which resulted in large losses to the growers of seed potatoes. Bacterial wilt and soft rot (probably ring rot) was present in some seed stocks of the Katahdin variety. This disease has been practically eliminated from the Spaulding

* This is an abstract of a paper by R. M. Bailey having the same title and published in the Proceedings of the Amer. Soc. for Hort. Sci. 36:645-646. 1938.

† This is an abstract of Maine Ext. Serv. Bul. 251 by Merna M. Monroe and Edna M. Cobb.

‡ This is an abstract of a paper by Reiner Bonde, having the same title and published in Plant Disease Reporter 22:457-460. 1938.

Rose variety by rigid field inspections and by the use of disease-free seed stocks.

The season of 1938 was very favorable for the development of late blight or "rust" and the loss from this disease was estimated at 15 per cent of the total crop. The amount of tuber decay caused by the late blight fungus was very great in some fields.

Pink rot, a disease caused by *Phytophthora* sp. is reported as occurring in Maine. This disease is of minor importance and occurs only in exclusively moist locations.

BACTERIAL WILT AND SOFT ROT OF THE POTATO*

This is a popular bulletin pertaining to the bacterial wilt and soft rot disease of the potato. The symptoms of the disease, the method by which it is spread, and the control measures are given.

BACTERIAL WILT AND SOFT ROT OF THE POTATO†

Growers of potatoes are cautioned to take measures to prevent this disease from spreading and causing large losses to the potato industry. The symptoms of the disease in the foliage and tubers are given. The methods of perpetuation, dissemination, and control measures are discussed briefly. The only practical method of combating wilt and soft rot is by the exclusive use of disease-free seed.

YIELD REDUCTION BY LIME SULPHUR ON APPLE TREES‡

In a young McIntosh apple orchard in Maine, 338 trees were studied for 11 years in 45 plots replicated in 5 series. The 5 series have received respectively: (1) dry lime sulphur spray every year; (2) lead arsenate 8 years and dry lime sulphur spray 3 years; (3) minimum of lead arsenate for leaf-chewing insects; (4) fine-sulphur spray; and (5) sulphur dust. The corresponding average trunk girths attained are 35.5, 35.7, 35.2, 36.7, and 35.0 cm., which

* This is an abstract of a paper by Reiner Bonde and Oscar Wyman, having the same title and published as Maine Agr. Ext. Service Bul. 258, 8 pp. 1938.

† This is an abstract of a paper by Reiner Bonde, having the same title and published in American Potato Journal 16:109-114. 1939.

‡ This is an abstract by Donald Folsom published under the same title in Phytopath. 29:6. 1939.

gives a range of only 5 per cent with the fine-sulphur spray and sulphur dust at the extremes. The corresponding yield rates per tree in 1938 were 11, 13, 34, 43, and 47 pounds, and, in 1933 to 1938, inclusive, were 47, 65, 78, 104, and 123 pounds. The 50 per cent reduction, in yield rate to date, by lime-sulphur spraying as compared with sulphur spraying and dusting, is highly significant, according to statistical analyses of plot and tree data.

METEOROLOGICAL OBSERVATIONS

The Station is indebted to the Department of Physics of the University for the meteorological summary for Orono for 1938 which appears on the following page.

The instruments used are located on the University campus at Lat. 44° 54′ 2″ N., Long. 68° 40′ 5″ W., Elevation 135 feet. They are the same as those used in preceding years and include: maximum and minimum thermometers, rain gauge, self-recording anemometer, vane, and barometers. The observations at Orono now form an almost unbroken record of seventy years.

METEOROLOGICAL SUMMARY FOR 1938

U. of M. Orono, Maine

1938	January	February	March	April	May	June	July	August	September	October	November	December	Average	Total
Highest temperature	52	45	66	84	80	94	90	98	80	86	78	57	—	—
Lowest temperature	−9	−6	−16	15	30	44	46	39	34	22	−7	−6	—	—
Mean temperature	19.47	21.89	30.01	46.44	53.19	68.20	68.80	70.65	56.9	50.58	37.61	25.69	45.79	
Total precipitation in inches	16.19	19.18	30.13	40.90	51.15	61.45	69.27	65.95	60.03	49.12	37.53	23.01	43.65	
Mean total precipitation in 70 years	3.03	2.65	2.35	2.06	3.92	2.68	3.72	1.51	6.39	3.14	2.71	4.64		38.80
Number of days with .01 inch precipitation or more	3.94	4.06	3.51	2.81	3.26	3.47	3.39	3.33	3.52	3.96	3.51	3.56	—	42.31
Snowfall in inches	6	9	9	6	12	9	14	10	13	5	8	10	—	111
Mean snowfall in 70 years	8.5	11	6	4	—	—	—	—	—	—	16.5	15	—	61
Number of clear days	21.08	20.83	13.57	5.27	—	—	—	—	—	.68	5.96	15	—	82.39
Number of partly cloudy days	9	9	10	8	7	9	4	9	9	13	7	15	—	99
Number of cloudy days	11	9	11	13	14	11	13	18	10	10	5	5	—	144
Average wind velocity in miles per hour	11	10	10	9	10	10	14	4	11	8	10	14	—	122
	5.72	6.37	4.93	4.87	4.43	5.11	5.20	4.74	4.31	3.68	4.81	4.62	4.90	

METEOROLOGICAL SUMMARY

U. of M. Orono, Maine

January-June, 1939

1939	January	February	March	April	May	June
Highest temperature	46	52	52	68	83	88
Lowest temperature	−12	−10	−4	20	29	34
Mean temperature	19.06	20.07	26.46	39.05	52.90	60.85
Mean temperature in 71 years	16.23	19.19	30.08	40.87	51.17	61.44
Total precipitation in inches	2.16	2.39	2.61	2.08	2.22	3.79
Mean total precipitation in 71 years	3.92	4.02	3.49	2.79	3.24	3.48
Number of days with .01 inch precipitation or more	6	10	6	8	10	10
Snowfall in inches	10	15.75	20.5	6.5	—	—
Mean snowfall in 71 years	20.92	20.76	13.67	5.29	—	—
Number of clear days	12	11	13	9	11	7
Number of partly cloudy days	13	7	8	12	13	15
Number of cloudy days	6	10	10	9	7	8
Average wind velocity in miles per hour	4.33	5.49	4.75	4.64	3.91	3.75

METEOROLOGICAL SUMMARY

Aroostook Farm, Presque Isle, Maine

January-June, 1939

1939	January	February	March	April	May	June
Highest temperature	41	36	40	51	76	85
Lowest temperature	−16	−12	−21	13	25	31
Mean temperature	10.5	11.1	16.8	34.6	50.0	59.0
Mean temperature in 13 years	12.8	12.4	23.7	37.5	50.5	60.2
Total precipitation in inches	1.04	1.85	2.29	4.30	1.92	2.00
Mean total precipitation in 13 years	2.34	1.37	2.21	2.46	3.15	3.57
Number of days with .01 inch precipitation or more	5	10	10	11	9	10
Snowfall in inches	5.50	15.00	15.70	10.00	—	—
Mean snowfall in 13 years	13.36	9.68	5.94	3.17	.01	—
Number of clear days	15	8	11	13	12	9
Number of partly cloudy days	1	4	8	5	11	8
Number of cloudy days*	14	16	12	12	8	12
Average wind velocity in miles per hour	—	—	—	—	—	—

* No information on condition of sky for one day in January and one day in June.

METEOROLOGICAL SUMMARY FOR 1938

Aroostook Farm, Presque Isle, Maine

1938	January	February	March	April	May	June	July	August	September	October	November	December	Average	Total
Highest temperature	45	37	47	68	80	89	81	86	78	71	62	51	—	—
Lowest temperature	−25	−21	−30	17	27	38	45	37	27	21	−4	−11	—	—
Mean temperature	8.5	10.7	20.2	38.0	46.2	62.3	63.8	63.4	50.8	42.6	28.4	19.0	37.8	
Mean temperature in 12 years 1927-1938	13.0	12.5	24.2	37.8	50.5	60.3	65.4	63.4	54.8	44.0	30.4	17.0	39.4	
Total precipitation in inches	1.38	0.88	0.77	2.71	3.35	3.80	5.06	6.03	2.87	1.97	2.04	3.56	—	34.42
Mean total precipitation in 12 years	2.44	1.33	2.20	2.31	3.25	3.70	4.09	3.34	3.64	3.55	2.21	2.09	—	34.16
Number of days with .01 inch precipitation or more	7	10	10	15	11	10	12	17	14	8	12	10	—	136
Snowfall in inches	4.00	9.50	5.00	4.00	—	—	—	—	—	—	9.00	9.50	—	41.00
Mean snowfall in 12 years	14.01	9.23	5.13	2.60	.01	—	—	—	—	1.60	3.78	11.36	—	47.72
Number of clear days	10	10	11	7	11	12	7	14	5	17	13	8	—	125
Number of partly cloudy days	8	6	6	8	9	7	6	1	8	3	4	4	—	70
Number of cloudy days	13	12	14	15	11	11	18	16	17	11	13	19	—	170
Average wind velocity in miles per hour	—	—	—	—	—	—	—	—	—	—	—	—	—	—

RAINFALL RECORDS, HIGHMOOR FARM, 1939

May to October, Inclusive

(Readings taken between 7:00 and 8:00 a.m. The figures indicate precipitation during past 24 hours.)

Day	May	June	July	August	September	October
	Rain (inches)	Rain (inches)	Rain (inches)	Rain (inches)	Rain (inches)	Rain (inches)
1	—	—	.64	.24	Trace	.06
2	—	—	Trace	Trace	.30	Trace
3	—	—	—	—	Trace	Trace
4	—	—	—	—	.01	.04
5	.01	.25	—	.88	—	Trace
6	—	Trace	—	—	.41	—
7	.04	—	Trace	—	Trace	.31
8	—	—	—	—	—	Trace
9	Trace	.01	—	.76	—	.06
10	Trace	.01	—	.04	—	—
11	—	Trace	.41	—	.74	.02
12	—	—	—	—	Trace	—
13	—	—	.01	—	—	.01
14	—	.54	.50	.50	—	Trace
15	—	.10	Trace	Trace	.02	.05
16	—	.06	—	—	—	.01
17	—	.21	—	1.16	—	—
18	.01	Trace	.10	.01	Trace	—
19	—	—	Trace	Trace	—	—
20	.04	—	—	Trace	Trace	—
21	.02	Trace	.23	.63	Trace	—
22	.02	—	Trace	.03	—	.08
23	.60	—	Trace	Trace	—	.29
24	Trace	.28	Trace	.01	—	—
25	—	.35	—	Trace	—	—
26	—	Trace	—	—	—	.01
27	—	—	.04	—	.18	.26
28	.02	Trace	1.18	—	2.10	.08
29	—	—	.09	Trace	.01	.28
30	.08	.28	Trace	—	.02	—
31	—		.10	—		.52
Total	.84	2.09	3.30	4.26	3.79	2.08

REPORT ON THE FINANCES OF THE STATION

The Station is a department of the University and its accounts are kept in the office of the Treasurer of the University. The books, voucher files, etc., are, however, all distinct from those of the other departments of the University. The classification of accounts is that prescribed by the auditors on the part of the Federal Government, and approved by the State Auditor. All of the accounts may be audited by the State Auditor, and the Hatch Fund, Adams Fund, Purnell Fund, and Bankhead-Jones Fund accounts are also audited by the Office of Experiment Stations acting for the Secretary of Agriculture of the United States in accordance with federal law.

The income of the Station from federal and state appropriations for the year that ended June 30, 1939, was:

U. S. Government, Hatch Fund	$15,000.00
U. S. Government, Adams Fund	15,000.00
U. S. Government, Purnell Fund	60,000.00
U. S. Government, Bankhead-Jones Fund	18,105.64
State of Maine, Mill Tax, Other Income, Sales, etc.	47,659.11
State Dept. of Agriculture (Inspection Analyses)	17,725.97
State Dept. of Agriculture (Potato Tax)	9,342.80
Printing	5,000.00
Fellowships	1,600.00
Total income	$189,433.52

The cost of maintaining the laboratories for the inspection analyses is borne by analysis fees and by the State Department of Agriculture. The income from sales at the experimental farms and the poultry plant is used for the expense of investigations.

At Aroostook Farm there are, in connection with the coöperative work with the Federal Department of Agriculture, certain expenditures for the Department made from sales of crops from Department investigations. These expenditures are not included in the tabular statements. They are carried as distinct and separate accounts, always with credit balances on the Station ledger.

REPORT OF THE TREASURER FOR THE YEAR ENDING JUNE 30, 1939

INCOME AND EXPENSE

Federal Funds

	Hatch	Adams	Purnell	Bankhead-Jones	Total
INCOME	$15,000.00	$15,000.00	$60,000.00	$18,105.64	$108,105.64
EXPENDITURES					
Salaries	7,208.37	10,766.52	39,846.20	13,273.22	71,094.31
Clerk Hire	1,000.00	—	1,000.00	—	2,000.00
Labor	988.38	2,940.76	7,728.89	2,638.44	14,296.47
Supplies and Materials	896.77	603.58	4,100.30	988.87	6,589.52
Communication Service	334.55	—	5.53	3.32	343.40
Travel	860.05	174.22	2,117.61	591.82	3,743.70
Transportation of Things	92.85	2.36	53.87	39.80	188.88
Printing and Illustrating Publications	4.50	—	65.04	—	69.54
Heat, Light, Water, and Power	1,489.37	—	300.06	—	1,789.43
Contingent Expenses	34.87	—	.25	—	35.12
Equipment	1,993.55	512.56	4,349.55	544.57	7,400.23
Buildings and Land	96.74	—	432.70	25.60	555.04
TOTAL EXPENDITURES	$15,000.00	$15,000.00	$60,000.00	$18,105.64	$108,105.64

REPORT OF THE TREASURER FOR THE YEAR ENDING JUNE 30, 1939

INCOME AND EXPENSE

State Funds

	Bankhead-Jones Offset	Maintenance	Aroostook Farm	General	Highmoor Farm	Inspection Analysis	Potato Tax	Printing	Total	Combined Total
INCOME	$18,105.64	$15,138.05	$8,386.73	$2,269.15	$ 3,759.54	$17,725.97	$9,342.80	$5,000.00	$79,727.88	$187,833.52
EXPENDITURES										
Salaries	11,707.35	1,949.97	897.96	—	1,082.46	12,355.05	1,116.66	—	29,109.45	100,203.76
Clerk Hire	—	—	—	—	—	—	—	—	—	2,000.00
Labor	2,566.20	1,996.20	3,465.96	772.00	3,033.11	3,432.66	1,046.13	—	16,312.26	30,608.73
Supplies and Materials	1,278.06	1,133.43	620.54	—	1,969.26	884.62	3,421.38	—	9,307.29	15,896.81
Communication Service	42.03	90.40	52.57	—	132.07	73.50	27.91	—	418.48	761.88
Travel	1,215.97	883.18	10.08	61.81	4.76	145.18	386.50	—	2,707.48	6,451.18
Transportation of Things	50.59	112.46	40.17	—	20.67	89.03	284.31	—	597.23	786.11
Printing and Illustrating										
Publications	40.77	35.39	—	—	—	—	9.85	5,000.00	5,086.01	5,155.55
Heat, Light, Water, and Power	65.87	164.98	848.70	119.82	2,140.81	471.90	11.12	—	3,823.20	5,612.63
Contingent Expenses	88.35	206.93	493.55	25.00	139.46	10.00	39.48	—	1,002.77	1,037.89
Equipment	606.77	1,211.45	1,614.30	27.15	944.73	239.73	2,991.34	—	7,635.47	15,035.70
Buildings and Land	443.68	720.72	1,330.91	4.84	775.48	24.30	8.12	—	3,308.05	3,863.09
TOTAL EXPENDITURES	$18,105.64	$ 8,505.11	$9,374.74	$1,010.62	$10,242.81	$17,725.97	$9,342.80	$5,000.00	$79,307.69	$187,413.33